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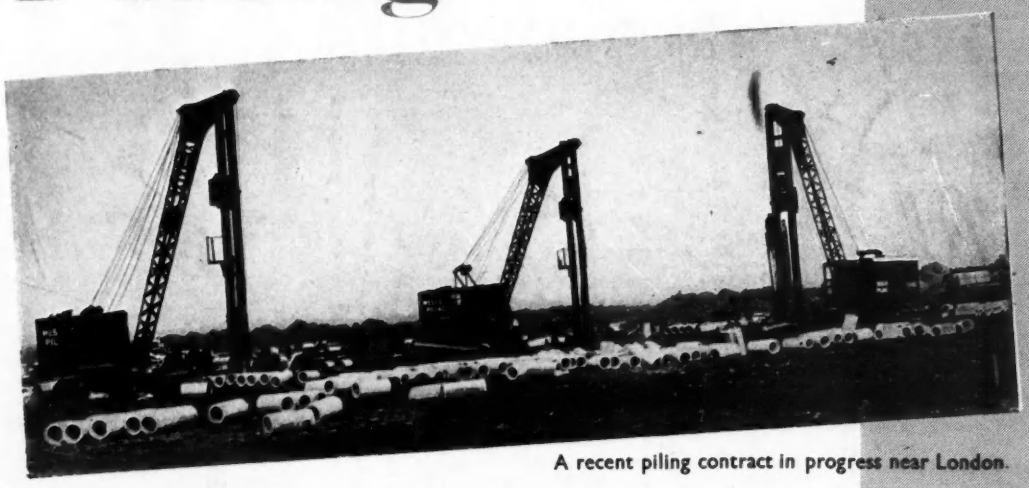

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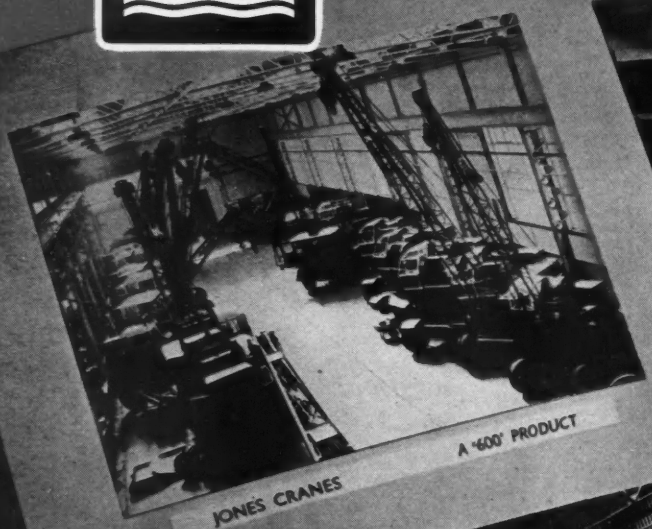

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Number One of a Series

THE ENGINEER

MAY 13, 1955

Conference on Engineering Standards

LAST week over 100 engineers concerned with the application of standards in many of the industrial organisations in this country met at British Standards House in London, under the joint auspices of the British Standards Institution and the Institution of Production Engineers. The main themes of the conference were the general problems of standards engineers in industry and consideration of the method of presentation of British Standards, with ways in which this might be improved to be of greater service to those who use them. The conference agreed that the status of the standards engineer should never be in doubt, nor should he have to "sell" standards to his company. It was also agreed that the standards engineeer should be free of departmental and sectional interests and should be concerned with the product at every stage of its development. Another opinion expressed at the conference was that data sheets would greatly facilitate the dissemination of the information in British Standards. Many large organisations would continue to prepare their own sheets, but the availability of loose sheets giving all the essential information required for a particular item would obviate much duplication of effort and encourage many more small concerns to use them. Sub-contractors and others dealing with orders from many sources would also benefit from the rationalisation which should result. The subject of a part-number coding system was somewhat controversial, it being stated that most large organisations had formulated such systems to suit their own needs. There was a general feeling, however, that the propagation of a standard code of part numbers, applicable to such items as screwed fasteners, for example, would have considerable advantages. It was also agreed that there need be no real difficulty in applying cross-references which would enable existing codes to continue in use where required. The conference concluded with resolutions to appoint a committee of standards engineers to discuss matters of general policy relating to the application of standards in industry and to hold regular conferences in future.

Plastic Design of Steel Frames

A DETAILED record of the design and erection experience gained over the past four years in building twelve single-storey structures, comprising steel portal frames designed according to the plastic theory, was given in a paper presented at the Institution of Civil Engineers yesterday, May 12th. The paper was entitled "Some Steel Structural Frames Designed on Plastic Theory," and was by D. H. Little and A. A. Smith, of the Admiralty civil engineering staff. The paper points out that if the whole of a steel framework, i.e. main members, purlins and sheeting rails, is designed closely to plastic theory quite remarkable savings in weight of steel can be achieved. Furthermore, if adequate precautions are taken to guard against lateral instability and to secure continuity or fixity, and also to deal with temporary erection deflections then, although sections may seem light by normal standards, fears as to excessive deflections and movements in the completed building are unlikely to materialise. However, some of the precautions and end preparations for welding may, especially with purlins, be so costly in money as to more than offset the gain by saving in weight. Now that welding costs appear to be approaching those for riveted and bolted work, the authors state, savings in both money and weight of steel can be achieved by designing main frames to plastic theory (but not too closely) and purlins, &c., to orthodox elastic theory. Site welding will be done readily enough if wanted, they note, but there seems to be a tendency for contractors to prefer to confine welding to shops and to use bolted connections for site. The combined use of bolting and welding is essential for a great deal of work sent out to be erected abroad and they consider that future development is likely to be on these lines. The paper includes a detailed discussion on bolted joints and tabular statements of weight and cost. Details of two other buildings designed on more orthodox lines are included for comparison.

Opening of Holme Sluices

A NEW sluice gate installation of the Trent River Board's Nottingham flood protection scheme—the Holme Sluices—was opened by H.R.H. the Duke of Edinburgh on May 5th. This installation, which replaces the old Colwick Weir, is claimed to be the largest installation of automatically operated sluices in Great Britain, the channel being spanned by five 40ft wide roller sluice gates, each 16ft 6in deep. The sluice gates are operated automatically by the rise and fall of the water and ensure that the river level upstream of the sluices is kept as low as possible while still providing enough water for navigation. Under flood conditions the gates will lift up to a height of 24ft, in which position they give an unobstructed flow of the river between the piers. The gates can also be operated electrically by push-button control, or in an emergency wherein the electric supply might have failed, by hand operation of the winches on the overhead structure above the gates. The works at Holme Sluices have been built to the designs of the Trent River Board, the civil engineering contractor being Sir Robert McAlpine and Sons (Midlands), Ltd. The sluice gates were supplied by Ransomes and Rapier, Ltd.

Annual Luncheon of the Electrical Research Association

A LUNCHEON on the occasion of the thirty-fourth annual general meeting of the British Electrical and Allied Industries Research Association was held at the Savoy Hotel, London, on Wednesday, May 4th. The toast of the E.R.A. was proposed by Viscount Woolton, who recalled that the E.R.A., since its early days, had sponsored extra-mural research, particularly at the universities. This was still true to-day when much of the more fundamental research work under E.R.A. auspices was done at universities. Scientific research, he said, was the life blood of technical progress and was worthwhile, irrespective of the immediate gain. It was important, however, to meet the criticism that Great Britain earned the credit for a great deal of basic research but then allowed other countries to apply the results and take the profit. There was urgent need, therefore, to encourage practically minded people to engage in research. Viscount Chandos, the new president of the E.R.A., in replying to the toast, referred to the immense improvement in living standards wrought by technological progress. The scale of growth was illustrated by the fact that the national revenue of the United Kingdom in 1955 was seven times the whole of the national debt in 1902. But the changes that had taken place in the past 50 years would be as nothing compared with the changes that could be foreseen in the next 50 years, for man's power to create wealth increased in geometrical, not arithmetical, progression. The electrical and the chemical industries were in the forefront of the agencies that could help to create this wealth. But, he said, Great Britain would not retain her position as a world power if she allowed herself to fall behind in the development of the peaceful uses of nuclear energy.

Royal Aeronautical Society

THE Royal Aeronautical Society has announced the award of its gold medal, which is the highest honour it bestows, to Lord Hives, chairman of Rolls-Royce, Ltd., in recognition of his work on aircraft propulsion. Silver medals have been awarded to Dr. R. A. Frazer, formerly deputy chief scientific officer in the Aerodynamics Division of the National Physical Laboratory, and to Dr. A. A. Griffith, chief research engineer of Rolls-Royce, Ltd. A bronze medal has been awarded to Professor M. J. Lighthill, of Manchester University. Other awards include the Wakefield gold medal to Mr. J. Taylor, for the designing of the counting accelerometer, and the British gold medal to Mr. G. H. Dowty, in recognition of his achievements in the design and development of aircraft accessories. Among the prize awards made by the Society are the R. P. Alston memorial prize to Mr. G. A. V. Tyson; the Edward Busk memorial prize to Mr. J. C. Wimpenny; the Herbert Akroyd Stuart memorial prize to Mr. E. E. Chatterton; the Usborne memorial prize to Mr. L. F. Crabtree; the Orville Wright prize to Mr. D. B. Spalding and Mr. B. S. Tall; the J. E. Hodgson prize to Major G. P. Bulman and Mr. J. Smith; the branch prize to Mr. E. Chambers, and the Society's navigation prize to Mr. J. F. W. Mercer. Awards are to be made from the "R38" memorial fund to Lord Ventry and Mr. W. N. Alcock to assist in investigations concerning airships. At the annual general meeting of the Society, which was held in London on Thursday of last week, Mr. N. E. Rowe took office as president in succession to Sir Sydney Camm. The retiring president announced that honorary fellowship of the Society had been accorded to Dr. Igor I. Sikorsky and to Mr. H. Grinsted.

Seaweed Research

THE Institute of Seaweed Research has published its report for 1954, and records in it that last year was one of the most successful in the history of the industry. It is stated that since the end of the war, the British alginate and seaweed meal producers have built up an industry worth over £600,000 a year, using annually more than 30,000 tons of an indigenous crop which, during the early part of this century, had been neglected. There are now six seaweed processing factories in Scotland and nine additional collecting centres have been brought into operation. The Institute has, therefore, been fully occupied at its headquarters at Inveresk and at its out-stations on research devoted to the solution of seaweed harvesting and utilisation problems. The report says, for example, that the mechanical harvesting of sub-littoral seaweed in British inshore waters has now been proved to be a feasible and reasonably cheap operation. It has been shown that twin belt harvesters, operating from slightly modified conventional motor fishing vessels should collect over 5000 tons in an average year. The section of the report which deals with the work of the Institute's mechanical engineering department gives some particulars about the development of the experimental belt harvester and comments on the progress made with the suction method of seaweed harvesting. There is also reference in the report to the work undertaken on the drying of seaweed and the extraction of constituent chemicals. The economics of the processes developed have now been studied and estimates of costs have been prepared.

Aerodynamic Buffeting of Bridges*

by C. SCRUTON, B.Sc., A.F.R.Ae.S., A.F.I.A.S.

The aerodynamic instability of suspension bridges has been the subject of much investigation since the spectacular failure of the Tacoma Narrows structure in the United States. In this article a form of instability brought about by a buffeting action due to the eddying wake from an existing bridge close to the site of a projected suspension bridge is studied. Model tests demonstrated that oscillations could be set up in this way under certain fortunately rare combinations of circumstances which were present at this site. The bridge concerned is the projected Runcorn-Widnes structure.

IN the early part of 1954 an investigation was carried out in the aerodynamics division of the National Physical Laboratory to assist in the design of a bridge over the River Mersey between Runcorn and Widnes.† The bridge is to replace the existing transporter bridge there, and at the time of the investigation it was intended that it should be a suspension bridge. The initial model tests of the investigation were directed towards achieving a design for the suspended structure which would be free from any tendency to oscillate in steady winds. This dynamic effect of wind is termed aerodynamic instability, and it has been the subject of several previous investigations,[1, 2, 3] both in this country and in the United States. While this work was in progress, attention was given to possible undesirable effects arising from the presence of an existing railway bridge in close proximity to the site proposed for the new bridge. Tests made to examine these effects indicated that oscillations of the suspension bridge would be set up by the buffeting action of the eddying wake from the railway bridge. The buffeting of tailplanes by the disturbed airflow from the wings of an aircraft is well known in aeronautical engineering, but the writer knows of no instance where oscillations due to buffeting have actually occurred on a bridge. Nevertheless, the model tests demonstrated that such oscillations of bridges could be produced in certain, fortunately rare, combinations of circumstances. These conditions prevail at the site proposed for the Runcorn-Widnes bridge. Since the oscillations due to aerodynamic instability are self-induced, they may be avoided by attention to the design of the proposed bridge. This does not apply to oscillations due to buffeting. For these, the complete remedy might be found either by alterations to the structure of the interfering bridge in order to modify and reduce the eddy formation, or by changing the site of the proposed bridge to one sufficiently far away to be outside the influence of this wake. It is to be expected that neither of these measures will usually be permissible, and they were not so for the proposed Runcorn-Widnes bridge. For this bridge, however, the model tests showed that considerable reductions of the buffeting amplitudes could be gained by re-siting it closer to the railway bridge than was originally planned. Further advantage was gained by modification to the design of the suspension bridge to give increased natural frequencies.

Partly because of the buffeting hazards, and partly for other reasons perhaps, the joint committee for the Runcorn-Widnes bridge now prefers a steel arch design and Parliamentary approval for this change is now being sought.

The investigation to be described involved tests of the behaviour of sectional models of the bridge in a wind tunnel. A sectional model (see Figs. 1 and 2) is a rigid model of a sample length of the suspended structure of the bridge, and it is mounted in the wind tunnel with its span horizontal and normal to the wind stream, so that it can oscillate either in a vertical motion to correspond to the vertical bending of the complete bridge, or in a pitching oscillation to correspond to the torsion of the complete bridge. For tests of aerodynamic stability, it is often convenient and sufficient to test with only one of these motions permitted, but for buffeting tests both motions should be present at the same time. The use of the results of such model tests for the prediction of aero-

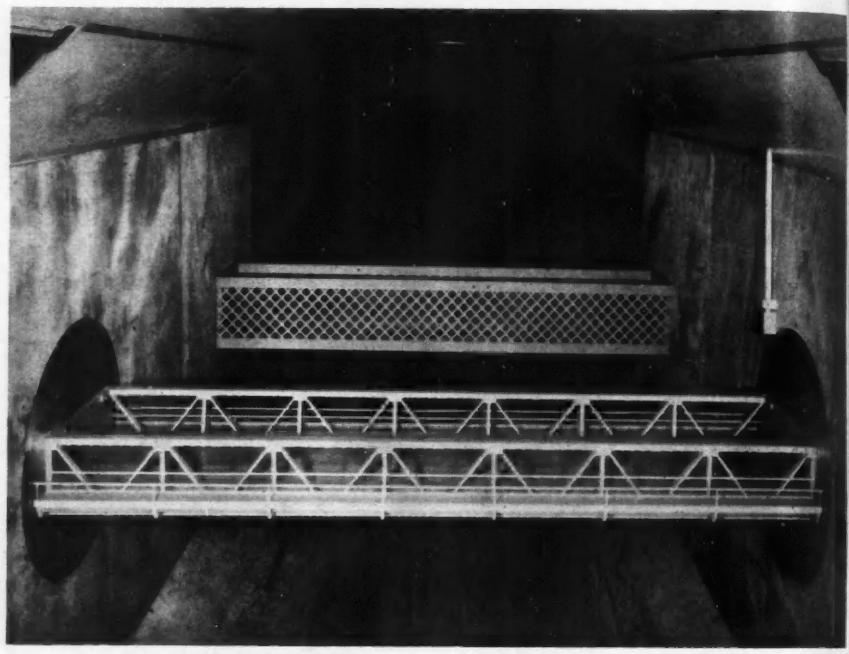

Fig. 1—Sectional model of the first suspension design proposed for the Runcorn-Widnes bridge (foreground) and model of the adjacent railway bridge (background)

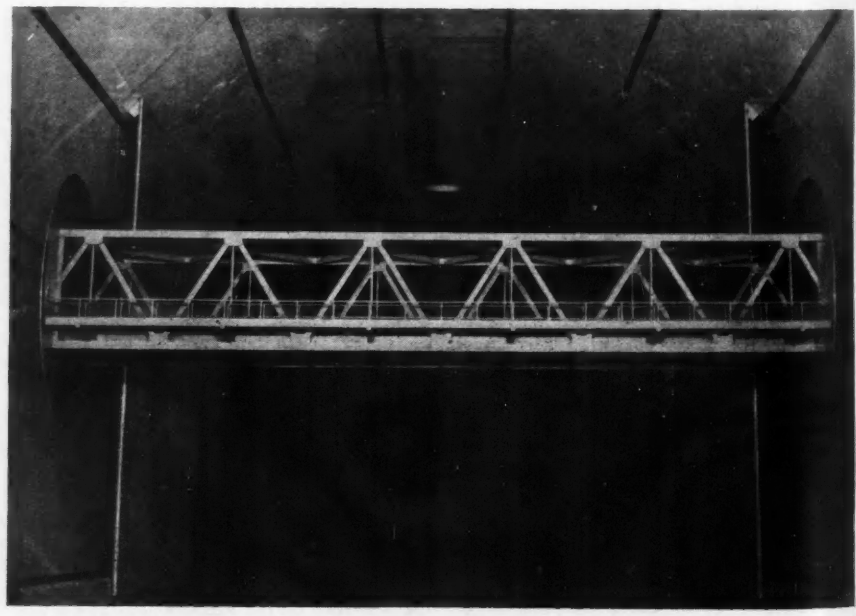

Fig. 2—Sectional model of the second suspension design proposed for the Runcorn-Widnes bridge

* Communication from the National Physical Laboratory.

† The investigation was made on behalf of the joint committee for the Runcorn-Widnes bridge at the request of Messrs. Mott, Hay and Anderson, the consulting engineers for the bridge.

SYMBOLS USED

V—Denotes the wind speed (m.p.h.).

N—Denotes the natural frequency of oscillation of the structure (c/s); suffixes z and θ respectively are used to indicate the frequencies of vertical and torsional modes.

B—Denotes a typical dimension, here taken as the width of bridge between the stiffening trusses (ft).

D—Denotes the clearance between adjacent trusses of the railway and suspension bridges (ft).

S—Denotes the Strouhal number, defined in the footnote on page 655.

f—Denotes the eddy frequency (c/s).

d—Denotes depth of the obstacle producing the eddies when projected in the direction of the wind stream.

v_F—Denotes the double amplitude due to buffeting of the vertical motion of the stiffening trusses at the quarter-span point of the complete bridge (in).

v_S—Denotes the double amplitude due to buffeting of the sectional bridge model scaled up to the dimensions of full-scale (in).

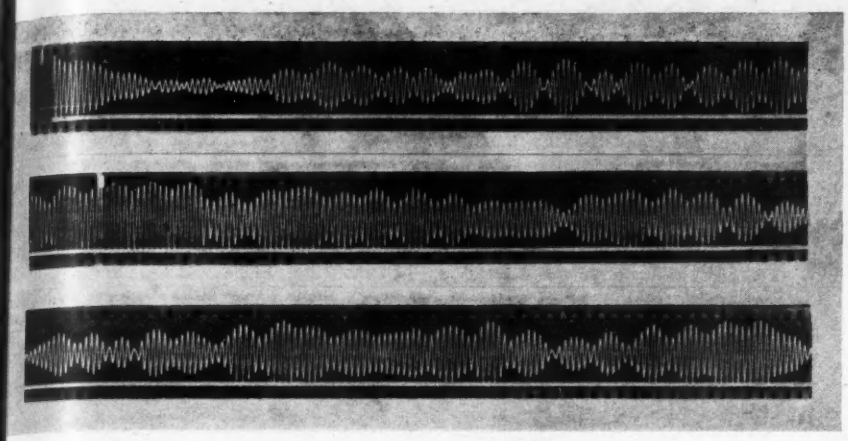

Fig. 3—Typical record of buffeting motion

dynamic stability was established by the aerodynamic investigations made for the proposed Severn bridge and the principles and methods governing their use are adequately described in the official and other reports.[2, 3, 4] The aerodynamic stability tests for the Runcorn-Widnes bridge will not be described here; but the buffeting action of wind presented a new problem which, it is believed, has not arisen previously in bridge design, and the main purpose of the present article is to record and to discuss the more important results given by the buffeting tests.

Prototype Prediction from Sectional Model Test Results

Although true similarity conditions are obviously not observed in sectional model tests, the conclusion was reached in the Severn bridge investigation that the critical values of the reduced velocity V/NB bounding the speed ranges for instability of a sectional model are directly applicable to the prototype provided the following conditions are satisfied.

(1) The external shape of model and prototype are similar.

(2) The inertial properties of the model are correctly scaled in relation to those of the prototype.

(3) The logarithmic decrement due to structural damping is the same for model as for full-scale.

Sectional model tests do not, however, yield directly the amplitude of the full-scale oscillations. From the standpoint of aerodynamic stability, critical wind speed alone is usually a sufficient criterion for assessing the merits of a particular design of bridge, whereas with buffeting the amplitudes are of paramount importance. As yet there is no available information on the buffeting behaviour of actual bridges which would enable a comparison to be made with the buffeting amplitudes found on sectional models, and in the present investigation correlation experiments with models of complete bridges were precluded because of the very considerable effort involved in the construction of such models and of the very large wind tunnel which would be required for their test. In the present state of knowledge the correlation between buffeting amplitudes found on sectional models and those on the prototype remains uncertain. However, when certain simplifying assumptions are made it is possible from considerations of energy to deduce theoretical factors of correlation. These factors are discussed very briefly in the appendix, and they should be used when assessing the significance of the amplitudes quoted in this paper, which have been obtained simply by multiplying the amplitudes found in the model tests by the ratio of the linear dimensions of the full-scale bridge to those of the model (32/1). The wind speeds quoted have been converted to refer to the full-scale bridge by substituting calculated values of the natural frequencies (see Table I) in the relation

$$(V/NB)_{model} = (V/NB)_{full\ scale}.$$

The Experiments

Photographs of the 1/32-scale models used in the tests are reproduced in Figs. 1 and 2. Each model of the suspension bridge represented a length of 174ft of the suspended structure of the 1030ft centre span. A similar length of the railway bridge was also reproduced. The actual railway bridge is a girder bridge with three equal spans of about 300ft, and it runs adjacent and nearly parallel to the centre span of the proposed bridge. In each span the solidity of the lattice decreases from about 50 per cent at the piers to 33 per cent at mid-span. The railway bridge model was not provided with lattice of graded solidity, but the model lattice could be changed to correspond with either of the above solidities. Model representations of the railway bridge piers and of railway trains were also used in conjunction with the railway bridge model for some of the tests. The railway bridge model was rigidly attached to the wind tunnel; the suspension bridge models were spring-mounted. Fig. 1 shows the model of the first design for the suspension bridge supported on the pitching-motion mounting used for tests of aerodynamic stability in the torsional modes of the complete bridge. For the buffeting tests this mounting was superseded by one providing freedom in both pitching and vertical motions. The model of the second design, shown in Fig. 2, is supported on this mounting; the arrangement consisted essentially of a four-wire support by spring tensioned wires placed so as to give the correct ratio of the pitching (torsional) to the vertical frequencies. Devices were incorporated for increasing the apparatus damping and for recording the motion.

The buffeting oscillations were of irregular amplitude (see Fig. 3) and their frequency corresponded to the natural frequency of the model for the type of oscillation produced. In general the vertical motion predominated at the lower wind speeds, but a greater proportion of "bursts" of torsional oscillations was found as the wind speed increased. The procedure adopted for measuring the buffeting amplitudes was to display the vertical amplitude of the motion of the bridge at a stiffening truss (whether due to vertical or to torsional motion) on a cathode-ray oscilloscope and to observe the maximum double amplitude reached during a period of two minutes with the wind speed at a specified value. This period corresponded on full-scale to between twelve and twenty minutes, the precise value depending on the frequency scale applicable to the test. For brevity the maximum double amplitude is termed the buffet, and the term maximum buffet is used to refer to the peak value of the buffet found within the range of wind speeds used in the tests.

Some results obtained with the model of

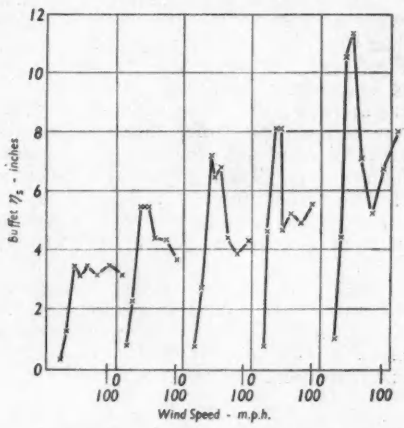

Fig. 4—Buffeting amplitudes—model of first design

the first design are reproduced in Figs. 4 and 5. These indicated a maximum buffet at a wind speed of a little over 40 m.p.h., and also that its value decreased approximately linearly as the horizontal clearance between the two bridges was reduced.‡ The maximum buffet with the suspension bridge sited as originally proposed was about 12in. It is reasonable to assume that the buffet maxima occur when the predominant frequency of the eddies shed by the railway bridge equals the natural frequency of the suspension bridge oscillation. It is interesting to note that for the railway bridge model fitted with the higher solidity lattice the experiments yielded a Strouhal frequency§ for the railway bridge

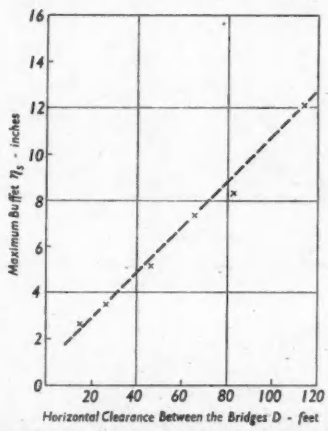

Fig. 5—Variation of maximum buffet with the distance apart of the railway and suspension bridges—model of first design

of between 0·14 and 0·17 if, as with a solid obstruction, the typical dimension d is taken as the total depth of the girder. These values may be compared with that of 0·15, which is

‡ This, of course, can apply only for small clearances. The buffets must eventually start to decrease and finally to disappear as the clearance is increased.

§ It is convenient to express the eddy frequency as a non-dimensional number which is often referred to as the Strouhal number S. $S = fd/V$

the commonly accepted value for a solid flat plate placed bluff to the wind.

The results quoted in Figs. 4 and 5 suggested practical ways of reducing the buffet, first by siting the proposed bridge closer to the railway bridge and, secondly, by increasing the natural frequencies of the suspension bridge. The latter measure would be expected to increase the wind speed at which the maximum buffet occurs since the Strouhal number for a sharp-edged body is generally found to be independent of wind speed, and hence the frequencies of the eddies shed by the railway bridge will increase in direct proportion to the wind speed. There were certain objections to reducing the horizontal clearance between the two bridges to less than 60ft, so that the full benefit indicated by Fig. 5 could not be realised. A second design of bridge (see Fig. 2) was prepared by the engineers, the suspended structure of which was considerably stiffer than that of the first, in order to provide higher natural frequencies. The important structural changes were an increase in the depth of the stiffening trusses from 16ft to 25ft and the incorporation of an overhead plane of bracing in addition to the one underneath the roadway. The effect of these changes on the calculated natural frequencies of the bridge in its fundamental antisymmetric mode of oscillation in vertical bending N_z and in torsion N_θ is shown in Table I.

TABLE I

	N_z c/s	N_θ c/s
First design	0·34	0·37
Second design	0·50	1·34

The buffeting tests of the model of the second design were carried out in winds inclined vertically relative to the model at angles of 10, 5, 0, −5 and −10 deg. The influence of wind incidence is summarised in graphical form in Fig. 6, which shows an increase of the maximum buffet with downward inclination of the wind. The results for a horizontal wind are given more fully in Fig. 7, together with those for the first design. Except perhaps when the horizontal clearance D=59ft, the expected 50 per cent increase in the wind speed for maximum buffet did not result from the increase in the frequency of the vertical motion. No explanation is offered for this apparent discrepancy, but it may be connected with the difference between the ratios of the frequencies of the torsional to the vertical oscillations of the two designs. However, the benefit gained by the increases in frequency was still substantial. For instance, a buffet of 4in, first reached at just under 40 m.p.h. with the first design, required a speed 10 m.p.h. higher with the second design. The effect of the increase of the solidity of the railway bridge due to the presence on it of a railway train is shown in Fig. 7(*b*). In this particular example the bigger buffet produced by the inclusion of the train was also accompanied by a change of the wind speed exciting the maximum buffet. This was not generally true ; for most of the conditions tested the maximum buffets increased due to the train, but they occurred at the same wind speed as when the train was not present. Fig. 7 also shows the effect of changing the solidity of the railway bridge lattice incorporated in the girder. The marked amplitude peak found with 50 per cent solidity lattice was scarcely evident with that of 33 per cent solidity, and the general level of the buffets was much lower. The results in general suggest that with the higher solidity lattice the dominant frequency of the eddies was controlled by the total depth of the girder, but that their buffeting strength depended on the solidity of the girder. With the lower solidity lattice the predominant buffeting eddies were probably those arising independently from the top and the bottom booms. Because of the small depth of the booms compared with the total depth of the girder the wind speed for coincidence of the eddy frequency with the bridge natural frequency was much lower, and hence the buffeting forces were smaller and were insufficient to cause large buffets even for conditions of resonance. To allow for the spanwise variation in the solidity of the railway bridge lattice the writer estimates that the buffets quoted for the higher solidity lattice should be multiplied by a factor of about 0·8. A further factor has to be applied to allow for the difference in the mode of oscillation of the sectional model and of the complete bridge. This rather difficult problem is discussed in the appendix. If we take the condition postulated last in the appendix as providing the maximum buffeting feasible, then the buffeting amplitudes quoted may be further multiplied by the factor 0·9, to make a total reduction factor of about 0·7. The buffets thus found refer to the displacements at the quarter-span positions only since the fundamental antisymmetric mode has been considered.

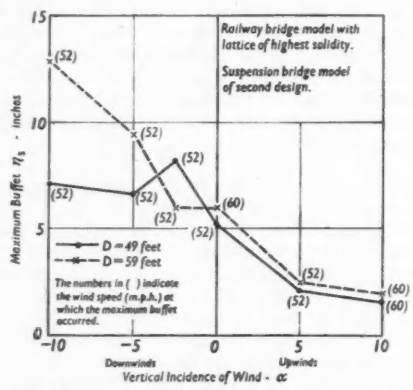
Railway bridge model with lattice of highest solidity.
Suspension bridge model of second design.
Maximum Buffet η_s - inches
D = 49 feet
D = 59 feet
The numbers in ( ) indicate the wind speed (m.p.h.) at which the maximum buffet occurred.
Downwinds
Upwinds
Vertical Incidence of Wind - α

Fig. 6—Influence on buffeting of the vertical inclination of the wind

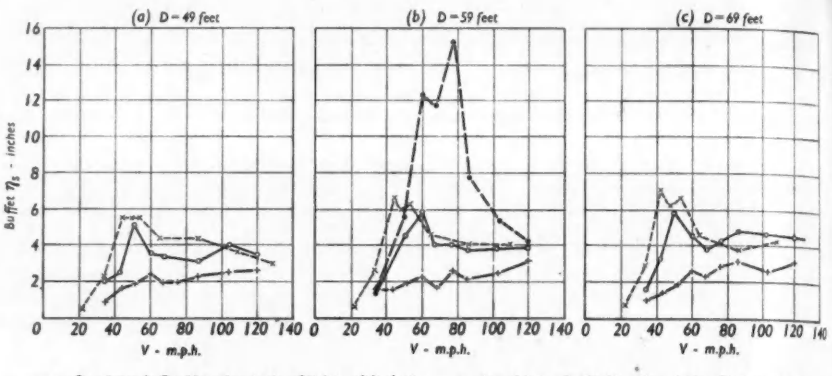
(a) D = 49 feet
(b) D = 59 feet
(c) D = 69 feet
Buffet η_s - inches
V - m.p.h.
First design, buffeted by railway bridge of highest solidity lattice.
Second design, buffeted by railway bridge of highest solidity lattice.
Second design, buffeted by railway bridge of highest solidity lattice with train.
Second design, buffeted by railway bridge of least solidity lattice.

Fig. 7—Buffeting amplitudes in horizontal winds

ACKNOWLEDGMENTS

This article is based on the results of an investigation carried out in the aerodynamics division of the National Physical Laboratory on behalf of the joint committee for the Runcorn-Widnes bridge. It is published by permission of the director of the Laboratory and with the approval of the engineers for the bridge, Messrs. Mott, Hay and Anderson. The author is indebted to these engineers for their close collaboration and advice, and also to his colleagues, Messrs. L. Woodgate and A. J. Alexander, for their able assistance in carrying out the experiments.

APPENDIX

PREDICTION OF FULL-SCALE BUFFETING AMPLITUDES FROM SECTIONAL MODEL TEST RESULTS

The buffeting action of the wind will tend to excite all modes of the complete bridge to some extent, but a mode with a natural frequency close to the predominant eddy frequency receives the greatest excitation. Since the eddy frequencies are proportional to wind speed, peak buffets will be reached first for the mode of lowest frequency. Exact agreement between the buffets of a complete bridge (η_F) and the scaled-up buffets found from sectional model tests (η_s) cannot be expected because of the incorrectly represented distortion modes. Moreover, the buffeting of a complete bridge must be especially sensitive to wind conditions ; even small variations in the wind front across the bridge span may produce important spanwise variations of the phase of the buffeting force. The natural wind conditions are not known in sufficient detail, and even if they were they could be reproduced in a wind tunnel for only a few simple cases. However, most types of wind front must appear at the site in course of time, and it is reasonable, therefore, to specify certain simplified fronts which enable the ratio η_F/η_s to be evaluated. The front considered

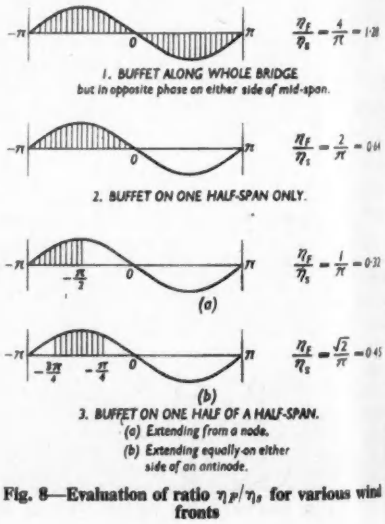
1. BUFFET ALONG WHOLE BRIDGE
but in opposite phase on either side of mid-span.
2. BUFFET ON ONE HALF-SPAN ONLY.
(a)
(b)
3. BUFFET ON ONE HALF OF A HALF-SPAN.
(a) Extending from a node.
(b) Extending equally on either side of an antinode.

Fig. 8—Evaluation of ratio η_F/η_s for various wind fronts

should, of course, include those producing the most severe buffeting, but in the final assessment consideration must be given to the likelihood of such conditions arising. The estimate of the ratio of η_P/η_s can be made simply from energy considerations when the wind front and the mode of oscillation are given. In the application to the Runcorn-Widnes bridge we consider the fundamental anti-symmetric mode in vertical bending, since this is the mode of lowest frequency. The estimated ratios, shown in Fig. 8, of the amplitudes are then obtained for the wind conditions specified. It should be noted that η_P is the amplitude at the quarter-span points of the complete bridge. The buffeting condition postulated in (1) of Fig. 8 is unlikely to occur in practice. Condition (2) is more likely. It is feasible that condition 3(*b*), or conditions which are the equivalent of 3(*b*), may occur simultaneously on both half-spans, but with opposite phase. In this case $\eta_P/\eta_s=0{\cdot}9$.

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The Transport Helicopter

By Dr. IGOR I. SIKORSKY, Mem.A.S.M.E.*

No. II—(*Concluded from page* 637, *May* 6*th*)

Abstracts from this James Clayton lecture, which was read by the author on April 29th, before the Institution of Mechanical Engineers, include a brief history of the helicopter and a review of present and future developments of this craft. Dr. Sikorsky particularly stresses the use of the helicopter using externally slung loads, and states his belief that the single mechanically driven rotor will dominate helicopter configurations for a long time.

Types of Helicopter

THE use of the term "transport helicopter" may call for certain explanations. For both the military and the commercial applications, it is possible to foresee, in the immediate future, the development of two distinct lines of design. The first would correspond and be similar to the airliner or transport airplane. The second would be a freight and cargo carrier, and would be a craft in its own class with virtually no parallel in any other aircraft or even in any other vehicle of travel.

Passenger Transport.—The first type would need very little description because it would be essentially the further development of the modern helicopter as currently used. With respect to certain items, however, the helicopter may gradually become somewhat different from the airliner. For instance, in the helicopter it would be desirable to use larger entrance doors, or more of them, in order to expedite the loading and unloading of the aircraft in the case of short-range flights. Furthermore, it would be desirable to use larger windows because, as a rule, the view from a helicopter cabin is completely unobstructed and the helicopter generally flies at lower altitude and, in the majority of cases, offers much more interesting scenery than that which could, on the average, be viewed from the airplane.

Freight Type.—The second and very interesting type whose appearance may confidently be expected in the near future, would be a special freight-cargo helicopter which would be specifically designed to lift any kind of object or load, including large and bulky ones, and to carry them on the outside, suspended below the body of the aircraft.

In the crane helicopter it is possible to use any conventional helicopter-lifting rotors and methods of control, power plant, transmissions, &c. The main difference would be in the body, location of the pilot's cabin, landing gear and powerful, special lifting crane devices that would allow for picking up an object, if necessary with the helicopter hovering over the ground. The cargo helicopter may virtually have no fuselage body as we know it and may simply represent a flying frame or possibly have a needle-like fuselage of small cross section adequate to accommodate the transmission and other accessories, and either a hoist or other arrangement that could be used to suspend and, if necessary, to lift the loads.

Study is being conducted as to the best configuration and the best location for the pilot's cabin in such aircraft. There are reasons for a novel arrangement in which the pilot's cabin would be suspended below a narrow tubular fuselage substantially behind the centre of gravity of the aircraft. Indeed, such location would somewhat obstruct upward vision from the pilot's cabin. However, with the very narrow fuselage the pilot would still have much better vision even in that direction than would the pilot of a "Zeppelin" or "Blimp," and yet the dirigible control cabin has proved to be satisfactory. Vision forward would be satisfactory while vision downward would be excellent.

The main advantage of such arrangement would be that the pilot would have excellent vision of the object which he is to lift, of the whole procedure of attaching and lifting and, finally, would have excellent opportunity to direct the aircraft in a way that would permit bringing and lowering the object, not merely on the geographical location, but actually and precisely where it may be needed. This would permit, for instance, carrying and lowering a transportable house directly upon its foundation, delivering high-tension towers in a vertical position and placing them accurately on their bases and, in fact, would combine the countless number of problems of transportation with the problems of actually lowering objects or materials, erecting machinery or sections of a bridge, &c., directly where they are intended to be. An excellent beginning of such service has already been made by the Armed Services and private operators, using ordinary helicopters. Among objects carried in such manner were jeeps, pieces of artillery, long pipes, long posts, loads of lumber to construct a village of twenty-one houses, light airplanes, helicopter bodies, miscellaneous pieces of machinery and equipment, food, fuel and a great variety of other objects, including a 300 lb cross which was lifted and set down directly on top of a church steeple.

Possible Future Development

An attempt will now be made to foresee the direction of the possible future development of the helicopter.

Simple Type.—First, we will analyse the case of the pure helicopter. By this term is meant an aircraft in which all lift and forward components are derived exclusively from the action of one or several lifting rotors. There are reasons to maintain that the operating speed of such aircraft will never be much in excess of 200 m.p.h. Several methods are being studied for the further increase of speed of the pure helicopter. Besides a general refinement of design and increase of power available, they include special designs of blades, different kinds of boundary layer control and, possibly, the use of supersonic blades.

I believe that some kind of boundary layer control to delay stalling would produce interesting results, although the increase in speed would not be great. In regard to the second method, it would seem that considerable difficulties, apart from the low efficiency and the noise factor, may preclude the practical use of supersonic rotors.

One of the major problems involved is connected with the fact that in forward flight a certain section of the blade would have to make the transition from subsonic to supersonic and back at each revolution. The adverse effect of such operation would be tremendous and alone might create insurmountable obstacles to the use of supersonic blades.

Compound Type.—A speed somewhat higher than the velocity of the pure helicopter could be obtained by the use of the compound helicopter or "gyrodyne." By this term is meant an aircraft which, besides the lifting rotor, has small auxiliary wings and probably propellers or jets. As the aircraft accelerates the wings will carry part of the load and, with the main rotor being unloaded, it would be possible to postpone or prevent stalling of the retreating blades and consequently exceed the speed range of the pure helicopter by perhaps 50 to 75 m.p.h. or even more.

As a rule, the wings and propulsive members of the compound helicopter would be, at best, useless during hovering. Consequently, with equal hovering ceiling and other conditions being identical, the compound helicopter should, as a rule, be expected to have less payload than the pure helicopter of comparable size and power. This fact, together with its greater simplicity and smaller maintenance cost, would most probably result in the pure helicopter remaining, for an indefinitely long period of time to come, a useful and popular type of aircraft that would be extensively utilised for a great variety of short-range missions. Nevertheless, for intermediate ranges, the compound helicopter, with its higher speed, may offer sufficient advantages to justify its use.

The simplest form of compound helicopter may be represented by a simple helicopter which carries some auxiliary means of propulsion, usually one or more propellers, driven fom the main source of power or from auxiliary engines or turbines. By relieving the forward component from the main rotor, it would undoubtedly be possible to obtain higher speeds than would be possible with the simple helicopter.

Convertible Type.—The more radical type, which would offer a considerable increase in speed, would be the so-called convertible helicopter. As the name signifies, it means an aircraft which can take off vertically and

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hover as an ordinary helicopter and then become converted into an airplane and travel at a considerable speed, perhaps several hundred miles per hour. I believe, however, that, as a general rule, such aircraft would always remain considerably more expensive and less efficient than either the pure helicopter or the pure airplane of equal lifting capacity. Therefore, I can foresee only a limited utilisation of the convertible type, mainly for certain specific military uses.

Vertical Take-Off Type.—A very promising aircraft of similar potential performance is the so-called V.T.O.—in other words, the vertical take-off airplane. I do not believe that it could even approach the hovering characteristics of a true helicopter with all the great safety and service significance of this regime.

Configuration

While it is possible to foresee a great variety of configurations using different numbers and arrangements of lifting rotors, and different methods of applying power, yet there are reasons to believe that a single-rotor aircraft—in other words, a helicopter in which all or most of the lift is derived from the action of one large rotor, would remain the most important type. At any rate, it appears so, judging from its performances and accomplishments to date. While different methods of transmitting and applying power may be visualised, yet for machines of up to 100 tons or so, the use of engines and a transmission carrying power to the rotor shaft, or directly to the rotor hub, seems to be the most practical. At present a metal gear transmission is used in the vast majority of practical helicopters. It is possible that hydraulic or pneumatic transmissions will make their appearance in the future if substantial further progress, in respect to efficiency, could be achieved in their design. At present no transmission of this type could even approach the 96 to 97 per cent of efficiency currently reached in well-designed modern metal gear transmissions of helicopters.

Concerning maintenance, life expectancy and reliability of helicopter transmissions, they are all quite reasonable even at the present time and may well be expected, in the near future, to be in line with the characteristics of the best modern aeronautical engines or turbines. It is believed, therefore, that piston engines or turbines, combined with the metal gear transmission, would represent the power unit for the majority of helicopters for an indefinitely long period of time to come.

In certain cases, particularly for still larger machines, it may be advantageous to eliminate the transmission and apply the force directly at the tips of the blades in the form of jets. It could possibly be in the form that had been considered by some leading engineers and had been well analysed and described in England by Mr. Fitzwilliams of Westland Aircraft—that is, mounting of the complete turbo-jet units on the tips of the lifting rotor blades.

While the construction of such aircraft would involve the serious engineering problem of producing a turbo-jet capable of withstanding considerable centrifugal and gyroscopic forces, it would also involve the problem of carrying heavy loads on the tips of the blades. In a super-giant aircraft of such nature, we may even foresee the blade supported by a landing gear of its own which may be retracted when the blade becomes airborne. Other methods may be suggested that would involve the use of supporting members that would be folded or removed when the blade becomes airborne or when the centrifugal force becomes sufficient to support the blade. In spite of the serious and novel problems which would be encountered, an aircraft of this type would certainly be possible. Such arrangement may become particularly interesting in a helicopter of a gross weight much in excess of 100 tons.

In respect to other characteristics, I believe it may be expected that in future helicopters, particularly in the large ones, we will use heavier disc loadings and lighter power loadings. While our study and experience indicate the advantages of a single-rotor configuration for all sizes, and particularly for the giant helicopter, yet in large rotors it may be advantageous to use a greater number of blades of a moderate chord. There are reasons to believe that this would increase the smoothness and decrease the control loads of the aircraft.

It is very probable that aircraft engines will continue to be the principal power plant on helicopters, as at present. However, we may confidently expect increased use of the turbine because the helicopter will profit even more from its characteristics than would the airplane. It is probable that, for the multiple-engined turbine-driven helicopter, engines with the free turbine wheel would be preferable because, in the event of one engine becoming inoperative, it would be possible to obtain nearly the full power of the remaining turbines at a somewhat reduced number of revolutions of the rotor. For single-engined helicopters this would represent no advantage and consequently ordinary shaft turbines would seem to be just as satisfactory.

The Use of Nuclear Power for Helicopters

Among the several arrangements that can be foreseen, one of the logical ones would seem to be as follows : We can visualise a turbine of generally conventional type in which the air, after being compressed, becomes overheated in a heat exchanger into which, in turn, heat is supplied from a nuclear reactor by circulating melted metal, or by some other means. The major problem in this case would still be to protect and insulate the occupants from the powerful radiation that would be created by the nuclear reactor. It is probable that on a sufficiently large machine a reactor could be situated far in the very bow of a fuselage of the aircraft and be properly insulated, while the crew could be located far behind, in the rear end of the craft. This, or similar solutions, however, may involve certain difficulties. It is probable that, during operation, the entire aircraft, including transmission and rotor blades, would become powerfully radioactive and the blades, in turn, would spread radioactivity on all parts of the aircraft, consequently making the method of protecting the crew extremely difficult, if not impossible.

Another method would be to separate completely the reactor, together with turbines, into one unit that could be carried by the helicopter, suspended on a length of cable about 200ft long or, if necessary, even more. By insulating either this unit or the crew compartment, or both, it would perhaps be possible to protect the occupants of the aircraft. However, in this case, transmission of power would present a serious problem.

A reasonable method would be to use the power of the turbine to generate compressed air, which can be sent by conduit up into the aircraft where it can operate power turbines or possibly be sent directly into the blades to turn them by means of jets. This, however, would still involve the danger of the stream of air passing the mechanisms inside the reactor and itself becoming infected with radiation which it would carry up into the aircraft. A safe way would be to generate electric current into the suspended reactor and send it up into the helicopter by means of wire. However, while some optimists believe that extremely lightweight generators and electric motors—weighing less than 1 lb per h.p.—are possible, yet any electrical equipment so far produced has been considerably heavier, and it remains a question of whether such light electric generators and motors can be produced.

The final arrangement, which, so far, appears to be the best, would be the reverse one. Let us suppose that the reactor, with all its accessories and the turbines directly geared to the rotor, are located in the cabin of the aircraft. However, no members of the crew occupy places in or even near the aircraft. They are all in a separate cabin which is normally suspended under the helicopter on a cable a couple of hundred feet long, and which, in fact, is never expected to be closer than that distance to the carrier helicopter. Controls will be transmitted from this suspended cabin into the helicopter by way of electricity or by other means which are entirely feasible. The aircraft would then be operated as follows :—

At the onset the helicopter is located on the ground 200ft or more from the cabin. From the cabin the pilot controls the helicopter takes it off, pilots it into vertical position above the cabin and, continuing slowly to climb, finally lifts the cabin and proceeds on his flight, with the cabin remaining suspended far below the helicopter. During landing, the procedure is reversed.

The greatest obstacle, which will probably prevent the use of atomic energy in helicopters for some time to come, is the fact that there may not be sufficient advantage in doing so. While very fast, nuclear-powered (possibly supersonic) airplanes with virtually unlimited flying range, would be tremendously valuable, yet practically all the missions of the helicopter are for short range, except in the case of ferrying of the aircraft, for which refuelling can usually be arranged without much difficulty. Consequently, it does not seem that the use of a delicate and very expensive source of power would be justified.

In the medium-size and large-size helicopters it may be advantageous, in the future, to use a combined system of application of power. As basic power, this would consist of engines or turbines whose power is geared to the main rotor shaft or, in larger units, preferably directly to the huge rotor hub of the aircraft. A secondary power system would consist of a turbine or turbines driving compressors, sending compressed air through the blades and using jet power at the tips of the blades with or without superheating it. Although the combined system appears more complicated than, for instance, a pure power-driven or pure jet-driven system, yet it may offer sufficient advantages to be considered particularly for large helicopters.

A considerable number of other arrangements that would permit transmitting of generating the power at the tip of the blade have already been proposed because, particularly for giant helicopters, it would seem very desirable to eliminate the torque together with the great stresses in the centre of the craft and the torque compensating device, by applying the entire power directly to the tips of the blades. So far, however, no arrangement of this nature has been tested that would approach the efficiency and general operating characteristics of a heli-

opter with a transmission and a torque-compensating control rotor. It is therefore not impossible that the conventional formula will survive even on giant helicopters. In certain designs of this nature it may be advantageous to use hydraulic, pneumatic or electric transmission of power to the tail rotor. It may even be desirable in some cases to eliminate the transmission by using a separate power plant, say, two governor-controlled turbines, to generate the power for the tail rotor where it is required.

Concerning the configuration of the aircraft, I believe that the giant and super-giant helicopter of the future will still be a single-rotor aircraft obviously having a huge rotor with a large number of blades and a very heavy disc loading.

As time goes on the helicopter will gradually assume the leading position as a guardian of life and property in emergencies.

These helicopters can carry provisions that would make possible the quick installation of such equipment as may be required by the immediate emergency. Such equipment may include fire fighting, medical equipment, instruments for detecting nuclear or biological poisons, &c. When much larger helicopters become available, and particularly with the advent of the freight-cargo type with a huge lifting capacity, such emergency equipment would be in the bigger and more important class. These may include transportable field hospitals, fully equipped, in a container, similar to a modern trailer, but without its height and width limitations.

Conclusion

Throughout the history of mankind there are few factors, if any, that have influenced human life and the course of history to a greater extent than the development of the means of travel.

The middle of the twentieth century witnessed the arrival of two new vehicles of travel, both of which are characterised by the elimination of certain speed barriers which, until recently, were considered impenetrable. On the side of high speed, we witnessed the arrival of the supersonic rocket-driven airplane. The possibility of man to fly with more than twice the velocity of sound, in other words, to move faster than the average revolver bullets and gun shells, represents one of the most spectacular achievements of human genius. There is no doubt that this aircraft is the forerunner of space craft and that within the lifetime of many of the present generation, man will be able to reach celestial space above the earth's atmosphere, and for the first time see and photograph the mother planet from interplanetary space. Whether or not landing on the moon can be attained within the current century remains to be seen, but the opening of space travel undoubtedly will be achieved. The significance of this cannot be overestimated and may in due time be regarded as one of the major events of all time. On the side of low speed, the arrival of the helicopter made possible the elimination of the minimum speed required for a controlled flight of a heavier-than-air craft. We can confidently foresee great expansion of the industries that make helicopters and the organisations that operate them.

British Industries Fair

No. III—(*Concluded from page 621, May 6th*)

THE British Industries Fair closes at Castle Bromwich and Olympia to-day, May 13th. Some of the engineering exhibits at Castle Bromwich are described below.

Aerograph Company, Ltd.

The paint-spraying equipment shown on the stand of the Aerograph Company, Ltd., 47, Holborn Viaduct, London, E.C.1, includes the automatic transverse spray coating machine illustrated in Fig. 15. This machine is designed to eliminate human variables in high-speed spraying work and impart a good quality finish with uniformity in thickness, colour and texture of the applied paint film.

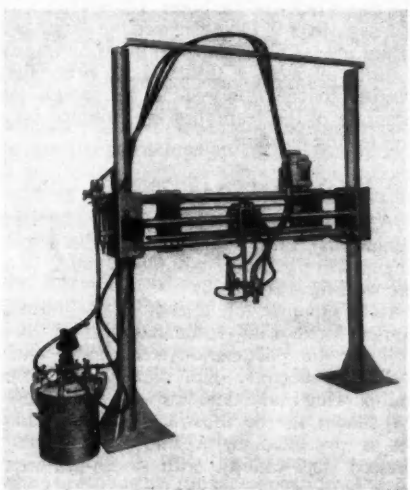


Fig. 15—Automatic transverse spray painting machine—Aerograph

The machine consists of a horizontal beam assembly supported by a pillar at each end and arranged to straddle a conveyor carrying the articles to be sprayed. The beam provides a track on which a spray gun mounting carriage is moved backwards and forwards by means of a chain driven by an electric motor. From one to four automatic spray guns can be mounted on the carriage, the number depending on the surface area to be coated.

Compressed-air-operated devices automatically open and close the guns at the beginning and end of each traverse, and there is also a manual control over-riding the automatic device so that the guns can easily be adjusted to coincide with the load carried by the conveyor. The finishing material is conveyed to the gun heads through flexible hose from a large pressure feed tank near the machine, or by pipeline in installations where mass production work is done on a very large scale.

The distance of traverse on a standard machine ranges from 2ft to 6ft and the guns can be set at varying angles to enable contoured surfaces to be coated. As long as one kind of finish is desired, a variety of shapes and sizes of flat work can be painted simultaneously.

Rover Gas Turbines, Ltd.

In an accompanying illustration (Fig. 16) we show a portable gas turbine alternator set which is being exhibited by Rover Gas Turbines, Ltd., of Meteor Works, Lode Lane, Solihull, Birmingham. The set is made by Petbow, Ltd., and is powered by a "Rover 1S/60" turbine rated continuously at 60 h.p. A description of this power unit, which weighs only 120 lb, has been given in The Engineer, April 9, 1954, page 527. The alternator, built by Macfarlane Engineering Company, Ltd., of Glasgow, in collaboration with Petbow, Ltd., is a 40kW, 50 c/s machine, rated to give 50kVA at 0·8 p.f., and is based on the "Magnicon" design. The set, which was recently demonstrated by

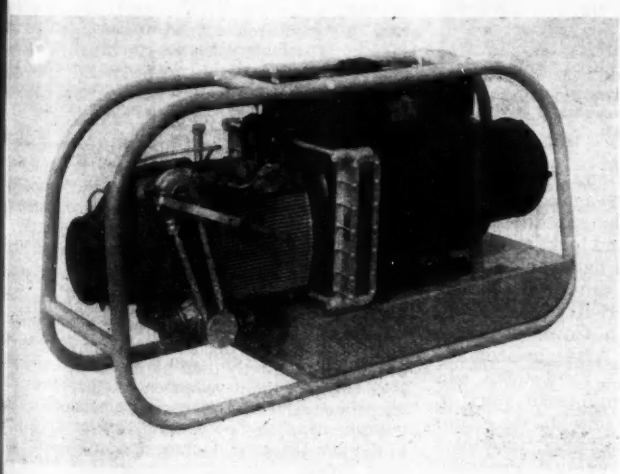
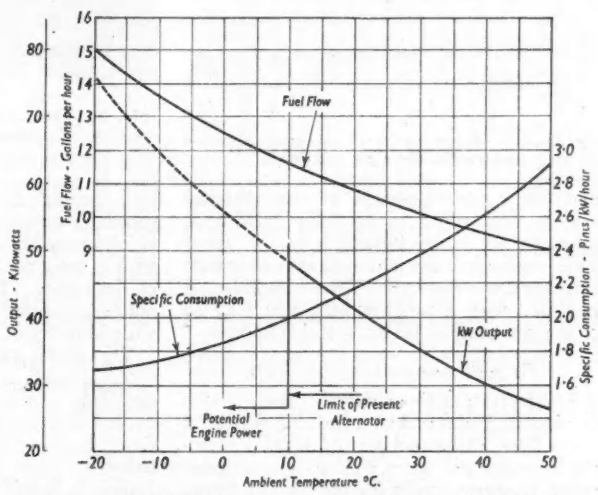


Fig. 16—40kW Petbow portable gas turbine generating set, consisting of Rover IS/60 gas turbine gear to a Macfarlane alternator—Rover



Turbine rotor speed, 47,000 r.p.m. Alternator speed, 3000 r.p.m. Fuel, diesel oil

Fig. 17—Performance and fuel consumption of 40kW Petbow gas turbine generating set, related to varying temperatures—Rover

Petbow, Ltd., at its factory at Sandwich, Kent, is self-regulating to within ±2 per cent of voltage at all rated loads and power factors. Speed is controlled to within 1 c/s of the nominal 50 c/s between no load and full load.

The set is mounted in a tubular steel framework which also supports a 20-gallon fuel tank, the total assembly weighing 1200 lb. The turbine rotates at 46,000 r.p.m. and at full power reaches an exhaust temperature of 600 deg. Cent. It is equipped for hand or electric starting, but can also be supplied with cartridge starter. For fuel it uses either distillates such as kerosene or diesel oil, or a gas such as natural gas, methane, sewage gas, or similar product. Performance curves are given in our second illustration (Fig. 17). The unit has been equipped with air filters, and oil coolers have been mounted on the alternator air outlets.

Colt Ventilation, Ltd.

A 12in diameter, 25W fan which, by splitting the air stream, provides both ventilation and extraction at the same time, is being introduced at Castle Bromwich by Colt Ventilation, Ltd., of Surbiton, Surrey. Our illustration (Fig. 18) shows one of these fans for window installation as seen from inside the room. The blades revolve in a plane at right angles to the window, through a slotted horizontal dividing plate. Both the inside and the outside portions of the spherical casing have ports in opposite quadrants, allowing air to be extracted by the upper half, while fresh air is drawn into the room through the lower half. The arrangement is provided with a weatherguard and may be closed when not in use by rotatable louvres.

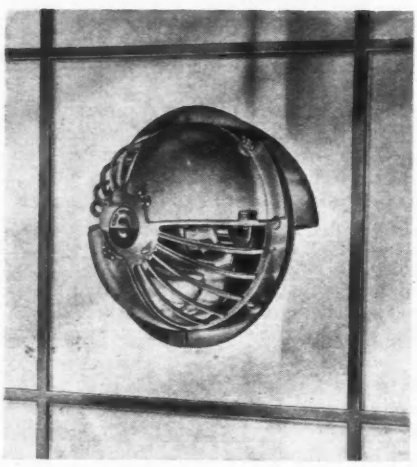


Fig. 18—12in window fan for simultaneous extraction and ventilation—Colt Ventilation

George Angus and Co., Ltd.

The representative selection of gears shown by George Angus and Co., Ltd., of Newcastle upon Tyne, includes a pair of unusual eccentric elliptical spur gears, similar to some gears made to special order for use on high-speed rotary tinplate shears being manufactured by W. H. A. Robertson and Co., Ltd. These gears, as can be seen in Fig. 19, operate in trains of three and the centre distance between each pair is 10in. As the gears operate at the high peripheral speed of 1000ft per minute and the tooth loading is high, particular care had to be taken in manufacture to ensure accuracy.

The gears have a face width of 6½in and the eccentricity of the bores is 0·8645in, with a difference of 0·140in between the major and minor axes. The maximum backlash in any position of mesh is 0·005in. In order that visitors to the firm's stand can check the accuracy of the gears they are mounted on a roll testing machine.

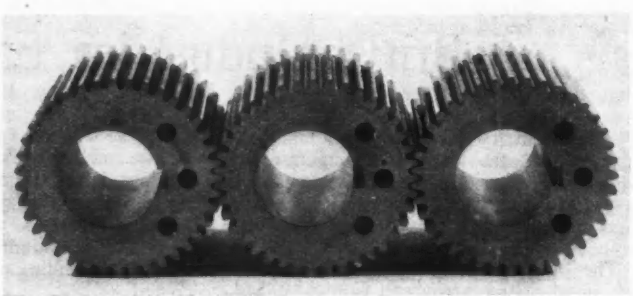


Fig. 19—Eccentric elliptical spur gears—Angus

A. C. Morrison (Engineers), Ltd.

A new exhibit shown by A. C. Morrison (Engineers), Ltd., Loughborough, is a petrol-engine-driven, trailer-mounted, 150A, d.c. arc welding set (Fig. 20).

It is mounted on a tubular-steel-framed trailer fitted with laminated springs, two 16in by 4in pneumatic-tyred wheels, mudguards, reflectors, 8in diameter overrun and parking brakes and a towing attachment. As shown in the illustration, the welding set is protected by a smooth contoured, pressed steel canopy, with screen-protected side openings for ventilation. Access to the generator controls and stowage compartment is obtained through a hinged door, fitted with a car-type handle and lock, at the rear of the trailer. Twin rear lights and number plates are fitted to the canopy to comply with Ministry of Transport Regulations.

Fig. 20—Petrol - engine - driven 150A d.c. arc welding set mounted on pneumatic tyred trailer —Morrison

The prime mover is a Coventry Victor "N" (Mark 2, model AN4) horizontally opposed, twin-cylinder, hand-start, air-cooled petrol engine, continuously rated to develop 19 b.h.p. at 2600 r.p.m., the engine being coupled to a Lincoln "Shield-Arc Junior" "S150" d.c. welding generator of the single-operator, variable-voltage design, fitted with class "B" insulation; it has a continuously rated output of 150A at 30V and a current range of 30A to 200A.

The generator is fitted with Lincoln "dual continuous control" of the welding current, which is designed to enable the desired arc characteristics to be obtained for welding to suit the job and the electrode. It provides for independent adjustment of current and voltage.

The 3-gallon fuel tank is covered by the canopy and a small hinged door gives access for filling. Tests indicate a fuel consumption at full load of 1¼ gallons per hour. The overall size of the welding set is 6ft from tow bar to rear lamps, 44in high and 38in wide over mudguards, the weight being 630 lb.

African Engineering News

BY OUR SOUTH AFRICAN CORRESPONDENT

Basutoland Dam Scheme

A final survey, expected to lead to the building of one of the most ambitious engineering projects ever undertaken in Southern Africa—a £10,000,000 dam and hydro-electric scheme near the source of the Orange River in the Basutoland Mountains—is being made by the Basutoland Government. The result of the survey, which will be submitted to the British Government for its consideration, is expected early this year. The dam is to be built in the Sekakes-Seforong district, only 12 miles from the source of the Orange River.

Doubling of Initial Output at Bancroft Copper Mine

Bancroft, the Rhodesian copper belt's newest mine, will double its initial production within three years, according to an announcement by the company. Production for 1960 should be 85,600 long tons of copper compared with an initial production of 42,800 long tons in 1957. This will be made possible by the expenditure of £5,000,000 in addition to the original estimate of £12,000,000. The additional £5,000,000 will be provided by the Anglo-American Corporation of South Africa, Ltd., and the British South Africa Company, Ltd. In return for this financial support, Anglo-American and the B.S.A. Company will be each granted an option, up to and including June, 1958, to take up 2,000,000 Ordinary 37s. 6d. shares in Bancroft Mines, Ltd. The doubling of production will be achieved by extending underground development and by fully utilising the capacity of shafts. The plant will be larger than originally estimated. An output of 85,600 tons per annum will make Bancroft Mine one of the largest producers of copper in Northern Rhodesia. The increased output is also expected to bring about reductions in the cost of production.

Africa's Largest Battery Factory

A £1,000,000 plant owned by Chloride Batteries, Ltd.—which is the largest factory of its kind in Africa—was opened in East London in March. The factory has its own coal grinding plant to provide coal dust which formerly had to be imported. It has its own demineralising plant for producing distilled water, a neutralising plant for dealing with acidified effluent and a purifying plant to prevent harmful fumes being released into the atmosphere. The factory occupies a floor space of 120,000 square feet and employs more than 300 Europeans and non-Europeans.

Manufacture in South Africa of Highly Specialised Electronic Equipment

The manufacturing unit of Standard Telephone and Cables, Ltd., in Johannesburg, is now actively engaged in the production of three and twelve-channel open-wire telephone systems of a kind extensively used by the South African Post Office in the development of the country's telephone and telegraph trunk-line network. The importance of this production development lies in the fact that manufacture in South Africa of light current electrical equipment has hitherto been confined to the production of relatively simple apparatus.

Iron and Steel Institute

No. II—(*Concluded from page 623, May 6th*)

At the Iron and Steel Institute's annual general meeting in London, the afternoon session on Wednesday, April 27th, was devoted to a joint discussion of the two following papers :—

CHARGING DELAYS DUE TO FURNACE BUNCHING

By R. Solt, B.Sc., A.M.I.E.E., A.M.I.Mech.E.

Synopsis

This paper sets out an operational analysis of charging open-hearth furnaces. In most melting shops the changing demand of the furnaces occasionally exceeds the capacity of the supply system and charging will be delayed. It may pay to install more equipment in order to reduce charging delays ; any such decision should be based on an evaluation of the charging delays suffered under existing and under proposed conditions. A method of evaluation is set out in the paper. The changing demand of the furnaces can be forecast by using an approximate probability theory.

THE SUPPLY OF SCRAP TO OPEN-HEARTH FURNACES

By M. D. J. Brisby and W. O. Pendray

Synopsis

This paper discusses problems in the supply of scrap to open-hearth furnaces. Supply systems have been investigated to find out what improvements are desirable and how they can be made. It was found that all melting shops suffer to some extent from charging delays, and recommendations are put forward for improving charging times.

Discussion

Mr. W. Evans (Steel Company of Wales, Ltd.) : Both papers have pointed out a necessary and embarrassing evil which is peculiarly associated with the manufacture of steel by the open-hearth process. Mr. Solt's paper, in particular, deals with some ingenious mathematical treatment of the probability that certain delays due to bunching will occur, but the paper does not offer us any remedies. Every open-hearth operator, to his cost, knows that bunching occurs. A great deal of thought has been brought to bear on the problem of how it can possibly be avoided, but unfortunately most operatives have come to the conclusion that the only means we have of avoiding bunching involve eventually a loss in production, which is a most important point. As Mr. Pendray said, if you have oxygen at your disposal and can blow every heat you make with oxygen, one way of dealing with bunching is not to blow certain heats, but you are only dropping tons per hour, which is not desirable. Another way of fighting it is to charge furnaces below their maximum capacity, which, again, is dropping tons per hour. Another way one thinks of is that instead of charging dead-low carbon heat one might charge higher carbon heat and get the furnace to run a little faster, but that means that you have to make the low carbon heat some time later, and if you carry this out you will get into trouble with the mills who will say that the heat should be made when they want it and not when you want it. It is not an overall solution. One can use the best scrap at one's disposal on certain heats but that means that you have worse scrap to charge another heat, and the same thing can be said of charging extra hot metal. There is some difficulty in organising these processes to avoid bunching in a busy shop, and one of the main points is where a shop is on a standard practice, or a number of shops try to adopt a standard practice so that quality and smoothness of operation will be ensured, because this sort of thing breaks up the standard practice in a shop, and probably is not desirable on that account and is not liked by a number of shop operators. Taking it altogether, we are bound to come to the conclusion that this necessary evil of bunching is costing the industry quite a lot of money. But, at the same time, open-hearth furnaces are not getting smaller; they are tending to get larger. This tends to make matters worse.

Mr. C. H. Bacon (John Summers and Son, Ltd.) : It is obviously important to have some idea of the optimum charging rate to a furnace and also of the expected improvement in output which there can be by arranging to get one's charging time down to this optimum. About a year ago we arranged to put some of the data from our furnace history sheets on to Hollerith cards and we analysed these on a three-monthly basis. For this purpose we found it necessary to divide our charges into four different grades, which are divided according to the percentage of hot metal and also the kind of liquid fuel used. As for the hot metal, at the present time we have not sufficient hot metal to make all our charges out of 65 per cent hot metal, which we should like to do, and rather than reduce the percentage on all charges, we find it preferable to make some of our charges with 65 per cent and the remainder with no ore, as a hot metal percentage of about 35 per cent.

Turning to the findings of the report, we find ourselves in close agreement with the recommendations put forward. Our organisation for the delivery of scrap to the furnace has recently been strengthened and includes one man who is responsible for the movement of traffic from the scrap sheds to the furnaces. He works very closely, on the one hand, with the scrap shed foreman and, on the other hand, with the materials checker, who is responsible for the allocation of scrap to the furnaces as required and also for the other materials—limestone, and so on. We are also paying very special attention to the question of the bogie return time to try to reduce that to the absolute minimum.

Mr. R. L. Knight (Broken Hill Proprietary Company, Ltd.) : The furnaces in the world to-day which are making steel on a straight basic open-hearth practice at the fastest rates are those which have the capacity and the equipment to put cold stock in the furnace at the rate of 100 tons per hour. In other words, if you have not the equipment to put cold stock into a modern shallow hearth —a hearth not greater in depth than 33in—at that rate, with a capacity to fire fuel up to a rate of 120 million B.Th.U. per hour, you are just not going to be in world class.

Mr. J. H. Flux (United Steel Company, Ltd.) : I think that the paper by Mr. Solt, in particular, has been a rather novel attempt to relate the effect of poor scrap and inadequate charging facilities on furnace operating time. If I may deal with the two papers together, I rather feel that the authors have not gone far enough in their positive suggestions for overcoming the problem of scrap handling and furnace charging. There is much more in it than just close attention to melting shop management and the problem will not be overcome just by generally attending to those aspects and by attending to a point which has been well covered this afternoon—shift change-over.

Mr. Solt has been aware, I think, of the difficulties in making the necessary assumptions to arrive at his mathematical equations, for he has remarked on this several times in the paper. Nevertheless, the rather general sweeping assumption on page 263—"that the charge-to-charge time T is constant and the same for all furnaces"—wipes out the whole problem of scrap charging and handling, I suggest. If it were possible to operate open-hearth furnaces on a constant charge-to-charge time, furnace bunching would not occur and all the operators would have to do would be to provide a known quantity of scrap at a known time. We should know months ahead how much we had to provide. I think that assumption is a little too sweeping. I wonder what the effect on the results would be if it were watered down.

Mr. W. L. James (John Lysaght, Ltd.) : We have to make use of the plant that we have. Some are more fortunate than others in this respect. I am particularly interested in the papers because my plant was one of those to which Mr. Brisby came for his experimental work. Please do not think that this is condemnatory of management at the moment. We know that management to-day is very difficult. We know that man-relations is very difficult. But a steel works does not consist only of plant. It has human beings, and it is getting the best out of them that brings results. I have always found that if you want the best results out of the workmen of this country you must talk to them and get down to them what you are after, and in ninety-nine cases out of 100 you will get a very prompt response.

Mr. H. G. Jones (Steel Company of Wales, Ltd.) also spoke, and showed some slides dealing with an investigation into factors influencing furnace charging.

The Institute's annual dinner took place on Wednesday evening, April 27th, at Grosvenor House, Park Lane, and was attended by a large company of members and their guests. Sir Charles Bruce-Gardner, Bt., the president, was in the chair, and responded to the toast "The Iron and Steel Institute and the Industry," which was proposed by Viscount Swinton, C.H. A toast to "The Guests" was proposed by Captain H. Leighton Davies and acknowledged by Lord Chandos.

The technical sessions were resumed on Thursday morning, April 28th, when the following papers were presented for joint discussion :—

CAUSES OF VARIABLE CREEP STRENGTH IN BASIC O.H. CARBON STEEL

By W. E. Bardgett, B.Sc., F.I.M., and M. G. Gemmill, B.Sc., A.I.M.

Synopsis

Creep and allied tests have been made on samples from fifty-eight basic open-hearth casts of carbon steel in which the aluminium additions ranged from 1 to 2½ lb per ton. The steels were selected with the object of determining the causes of variation in their creep strength. The reaction of oxygen during steel-making was examined for ten casts in relation to aluminium recovery ; it has been shown that the soluble aluminium present in the steel is a paramount factor in the variable creep behaviour, whilst the McQuaid-Ehn grain size is also related to it. Further consideration of these features has led to the view that the creep resistance of any of the steels correlates directly with the aluminium nitride content, which in turn is related to the soluble aluminium content and grain-size characteristics of the steel. From a practical point of view it would appear that steels of good creep resistance can be obtained with aluminium additions of up to 1½ lb per ton, provided that mould additions of aluminium are limited.

CREEP AND RUPTURE DATA ON MOLYBDENUM, CHROMIUM-MOLYBDENUM, AND MOLYBDENUM-VANADIUM STEELS

By J. Glen, B.Sc., F.I.M.

Synopsis

Creep tests have been carried out to show how the creep resistance of a steel changes owing to the effect of prolonged exposure to stress and temperature.

The effect of prior heat-treatment on this change is also considered and the limitations of short-time creep tests are discussed. Long-time creep and rupture tests have been carried out on test pieces from about ten open-hearth casts of each of three types of steel : 0·5 per cent Mo ; 0·8 per cent Cr, 0·5 per cent Mo ; and 0·5 per cent Mo, 0·25 per cent V. From these data an estimate has been made of the creep and rupture strength for a life of 100,000 hours. The results show that the Mo-V steel has creep and rupture properties much superior to the other two steels.

The elongation at fracture of the rupture tests was measured, and it was noted that at any given temperature the elongation at fracture first decreased with increasing time to fracture and then increased with still longer times. It was also noted that as the temperature of testing was reduced a longer time was required to reach the minimum elongation and that the value of elongation at the minimum decreased with decreasing temperature. The elongation of the 0·5 per cent Mo steel became very low with long times of testing, but the elongation of the Cr-Mo and Mo-V steels remained high even in periods approaching 100,000 hours.

RELATIONSHIPS BETWEEN LONG AND SHORT-TIME CREEP AND TENSILE PROPERTIES OF A COMMERCIAL ALLOY

By A. Graham, M.Sc., D.I.C., and K. F. A. Walles, B.A.

Synopsis

Experimental results are given for short-time creep tests, two forms of tension test, and creep-recovery tests, on Nimonic 80, and comparisons are made between these and with long-time creep data for Nimonic 80 type alloys. The results were used to guide the development of a theory of deformation, based upon the Nutting equation and the Boltzmann memory principle, which meets a variety of requirements. Satisfactory relationships are established amongst the various results and the long-time data.

STATISTICAL STUDY OF CREEP AND FATIGUE PROPERTIES OF A PRECISION-CAST HIGH-TEMPERATURE ALLOY

By G. T. Harris, M.A., F.I.M., and H. C. Child, B.Sc., A.I.M.

Discussion

Dr. J. O. Ward (Hadfields, Ltd.) : Turning to the paper by Harris and Child, we consider that this is a most timely and valuable contribution on the properties of investment cast moving blade materials. The process of investment casting has been widely used in the U.S.A. for the production of both moving and stator blades for jet engines, but in this country it has been essentially confined to the production of stator blades, because there has been a reluctance on the part of the designers to use cast moving components.

From the author's opening remarks, it could be inferred, no doubt incorrectly, that investment cast moving blades are used in the U.S.A. because they can produce sounder castings than can be produced in this country. We should like to emphasise that this is indeed a fallacy. We would suggest that, in approaching the problem of jet engine design, the U.S. designers have borne in mind the difficulty of production of such complicated components as blades and have first of all decided that if the casting method is to be used, then the ultimate design of blade should be suited to this method of production, whereas in this country emphasis has been on efficiency of design, even if this means expensive complicated methods of production. It would appear that in the future moving blades will have to withstand higher temperatures and stresses and, therefore, such alloys may well be virtually unmachinable and unforgeable. It appears that the most suitable alternative method to machining from forged or extruded material at the present time is investment casting.

Mr. B. B. Overy (University of London) : I should like to comment particularly this morning on the paper by Mr. Graham and Mr. Walles. I am particularly interested in the way in which they have tried to improve on the existing Nutting Law, which now seems to have some fairly well-accepted advantages and disadvantages. The chief advantage of the Nutting Law as it stands is that the Law will fit the results of any test series which give straight line log-log graphs of stress versus time, strain versus time, or stress versus strain, that being a very common feature in some of our creep results. Furthermore, the Law bridges the gap between Hooke's Law and the laws of viscous flow. It should be noted, however, that in tests where the Nutting Law has been verified, it has been usual to adopt some definite method of loading, such as constant stress, controlled strain, rate, or controlled rate of application of stress.

Mr. R. Wood (Mond Nickel Company, Ltd.) : I shall comment only on the paper by Mr. Graham and Mr. Walles. At the Mond Nickel Company's laboratories we have followed the authors' development of their methods of correlating short-term and long-time creep results with great interest, since they have done so much work upon our nimonic alloys. We feel that their work forms a great contribution to the derivation of practical methods of prediction of long-time creep behaviour from shorter time data. In view of that interest, one of my colleagues has applied the methods of the paper to some of our long-time creep test results on alloys Nimonic 60A and Nimonic 90. He has used both results which we supplied to Mr. Graham and some from more recent experiments. We have found that for several of our creep curves for Nimonic 90 the discrepancy between calculated and experimental values of strain over times up to 1800 hours did not exceed 7 per cent of the experimental values. Most of our work has been concerned with the practical application of Mr. Graham's parameter per square inch in the prediction of very long-time creep behaviour. Our findings indicate that this prediction by the authors' methods must be limited in scope, particularly in the duration, to which it can safely be applied.

At the concluding session on Thursday afternoon, April 28th, the papers discussed were :—

THE LIQUIDUS OF METAL-OXIDE/V_2O_5 SYSTEMS AND THE MECHANISM OF ACCELERATED ATTACK ON METALS BY V_2O_5

By G. Lucas, Ph.D., A.I.M., M. Weddle, M.Sc., and A. Preece, M.Sc., F.I.M.

Synopsis

The liquidus of a number of vanadium-pentoxide/metal-oxide systems has been determined using the Seger cone method. A study has also been made of the attack of vanadium pentoxide on chromium at high temperatures. The results have shown that alloys which resist oxidation by virtue of a protective film of chromic oxide lose this property in the presence of vanadium pentoxide.

EFFECT OF THE COMPOSITION OF GAS-TURBINE ALLOYS ON RESISTANCE TO SCALING AND TO VANADIUM PENTOXIDE ATTACK

By G. T. Harris, M.A., F.I.M., H. C. Child, B.Sc., A.I.M., and J. A. Kerr, B.Met.

Synopsis

The scale resistance in moving air of some typical gas-turbine alloys with and without coatings of vanadium pentoxide has been studied throughout their useful temperature range. The duration of the tests has been up to 1120 hours in seventy-hour cycles. In all cases vanadium pentoxide coatings have a deleterious effect, which is most pronounced for iron-base alloys, and at temperatures above 750 deg. Cent.

A systematic study has also been made of the effect of the base composition (iron, cobalt, nickel and chromium) and of added strengthening elements (molybdenum, tungsten, niobium, vanadium and titanium) on the scale resistance with and without vanadium pentoxide coatings. General conclusions have been drawn about the composition requirements if the maximum resistance to vanadium pentoxide attainable with austenitic materials is to be achieved.

Molybdenum additions have been shown to be permissible to materials containing 30 per cent of iron, or less, without causing undue scaling at 900 deg. Cent. in still or moving air. The drastic effect of still air on iron-base compositions containing molybdenum and vanadium has been confirmed.

Discussion

Mr. H. T. Shirley (Brown, Firth Research Laboratories) : We have new engineering parts which have to be kept to within reasonably fine limits, and the vanadium problem is with us. The interactions of many other things, such as sulphates, and so on, either by themselves or with vanadium, are completely reversing the picture. I would make a plea for considering these papers in the light of those facts. Any new acquisition of data in this complex field is very valuable.

In their paper, Harris, Child and Kerr have been very careful in their deductions. They have been cautious and that is a very wise policy. It is very tempting to translate your laboratory data into practical advice to engineers. At the moment the laboratory tests are particularly valuable in pointing to dominant factors. When you have trouble in practice, the laboratory tests may help to point out the dominant factors, but do not try unduly to press the process in reverse. I noticed on page 241 the suggestion that 550 deg. Cent. was the top working temperature. That is too pessimistic. Gas turbines are operating at rather higher temperatures than that, certain types operating at up to 600 deg. Cent. and perhaps well above that. I would draw your attention to the fact that a lot of the work has been done at very much higher temperatures. That underlines the need for action in trying to draw deductions for the gas turbine. There is a need to do more tests at a temperature 200–300 deg. higher.

With regard to the paper by Lucas, Weddle and Preece, the work on melting points is very interesting indeed. It is not nearly as practically interesting as perhaps it was a few years ago when, presumably, the work first took shape in the minds of the investigators. Look at the results. You will see how easy it is according to the curves to raise the melting point by mixing something with it. Leave out the engineering difficulty ; just imagine that we have mixed them. But if you do so, in my experience, aluminium oxide will disappoint you. Calcium and magnesium will not be satisfactory, and zinc will give you inhibition but will sulphate under the oil-burning conditions to varying degrees and will probably fail you. You will see from the paper how much diffusion through chromium oxide spoils any protective properties which it might have been hoped it would have. We have been doing tests with a lot of different alloys, and in particular 0·26 chromium steel or iron has given some exceptional resistance to practical conditions. That is very surprising. That applies to laboratory tests and practical tests. It indicates that there are a lot of other complications as well as the effects of pure V_2O_5, but it is very important to know what the V_2O_5 itself will do, and that is where the authors have served us well.

Mr. G. Burns (Royal Naval Scientific Service) : The method of determining the oxidation rate employed by the authors has shown the very marked increase in oxidation rate which occurs in heat-resisting alloys above certain temperatures, but what it does not show is a rather curious feature of the oxidation of G.18B and some other high-temperature alloys when they get above a certain temperature. A certain amount of work was done at the Admiralty Material

Laboratory a while ago in which cylindrical specimens of the material, 1·4cm diameter by 0·9cm, were placed in silica thimbles suspended from one arm of a balance into a vertical tube furnace, through which so far as was possible we restricted the air supply so as not to disturb the conditions, and continuously weighed during the test of 1000 hours.

Professor Preece and his co-workers show clearly that the oxidation of chromium at 700 deg. Cent. is accelerated by contact with vanadium pentoxide, and deduce from this that the use of chromium as an element conferring oxidation resistance is ineffective in the presence of this substance. This deduction seems rather sweeping when considered in the light of the results given by Harris, Child and Kerr, which indicate that, though chromium does not eliminate accelerated oxidation in the presence of vanadium pentoxide, it does effect some reduction. This is supported by the results of some tests at Admiralty Materials Laboratory, which showed that an alloy containing 20 per cent chromium was substantially more resistant to oxidation in the presence of vanadium pentoxide than were alloys containing only 14 per cent chromium.

Mr. K. Sachs (G.K.N. Research Laboratories): The destruction of materials exposed to ashes rich in vanadium pentoxide at temperatures above its melting point is a very serious problem. I think it would be fair to say that no metallurgical solution has yet been found. At present there is no alloy which can withstand vanadium pentoxide attack and no method of making the oil ash harmless. It is necessary, therefore, to assess the degree of deterioration of various existing alloys, and work of this kind has been going on all over the place. The paper by Harris, Child and Kerr is a very valuable contribution to the body of information on this subject. It is interesting to compare their results with those of a similar investigation carried out some time ago by Dr. Betteridge, Mr. Lewis and myself, into the effect of vanadium pentoxide contamination, both pure vanadium pentoxide and various mixtures with sodium sulphate, on a scaling resistance and stress-rupture life of alloys used in gas turbines. Our grading of the alloys in order of resistance to V_2O_5 attack was roughly similar to that indicated by Harris, Child and Kerr. In comparing the life to rupture of test bars carrying a coating of contaminant with that of clean bars, it was found that in alloys with 12–20 per cent chromium there was a continuous gradual improvement as iron was replaced by nickel. I must say that the steps were fairly broad, and we did not deal particularly with the narrow gap round about 25 per cent nickel, which has been found to be particularly susceptible. We found that cobalt additions seemed to have rather peculiar effects. High cobalt contents, about 50 per cent, behaved rather similarly to equivalent amounts of iron, while low additions, about 10–20 per cent, gave shorter lives than were found in any cobalt-free alloys. This can be partially accounted for by the fact that the cobalt-containing alloys in clean bars had rather longer lives and they have somewhat better stress-rupture lives, but there were examples, particularly in the case of nickel-based alloys, where the life of the cobalt-free alloy was reduced from 300 to 220 hours and that of an alloy containing 20 per cent cobalt was reduced from 270 hours to 73 hours. Moreover, while nothing could seen in the structure at 750 deg. Cent., the temperature at which the tests were carried out, in order to see what would happen if one went to extremes we carried out a few pilot experiments heating samples of the alloys at 1000 deg. Cent. and we found that iron-based alloys up to about 50 per cent iron gave a spongy scale and a relatively smooth surface with rapid removal of the metal, while at higher nickel contents one got a little intergranular penetration in advance of the main scale. It was significant that in the case of alloys with 20 per cent cobalt this intergranular penetration at 1000 deg. Cent. was very much deeper and more pronounced than in the case of cobalt-free alloys.

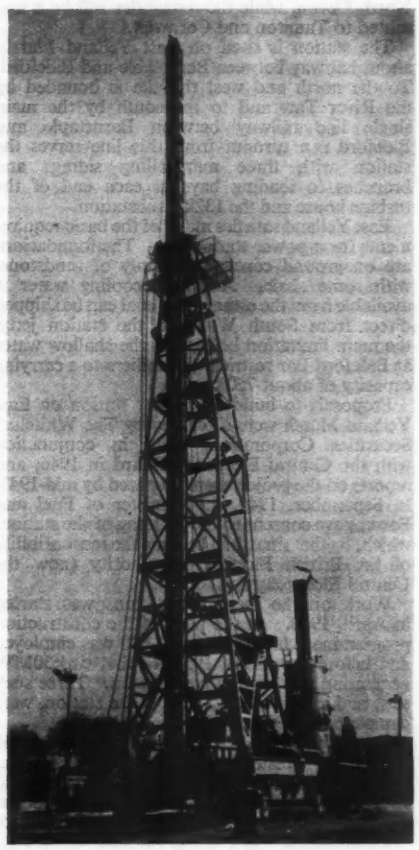
Dr. F. H. Davis (Metropolitan-Vickers Electrical Company, Ltd.): I should like to approach the problem from the engineering aspect, since we are interested in making engines which will operate on heavy fuel. I suggest that scaling factors are not necessarily a measure of the effectiveness of these materials in relation to behaviour or resistance to attack in a turbine. I say this because the authors, particularly Harris and his co-workers, have not attempted to examine—at any rate, they have not reported it—the microscopic structures, for instance, and then discussed the mode of attack. We have found in running an engine on heavy fuel—it was an engine with a nominal inlet temperature of 650 deg. Cent., but, owing to certain circumstances, in certain parts the temperature rose to 800 deg. Cent.—the attack on the nickel-based alloy Nimonic was serious in that it was intercrystalline and penetrated several thousandths of an inch in depth and would materially affect the fatigue strength, at least before there was a serious loss of dimension. On the other hand, a simple austenitic alloy without precipitants, such as the 18/8, gave a better result, a simple pitting attack which was much more innocuous.

Secondly, I suggest that they have been too mean in their additions of vanadium pentoxide in relation to what would obtain in practice. If I read it correctly, I think they have added about 1½ mg. per square centimetre in seventy hours. From our experience based on an estimate of what goes through an engine and what we find in the blades, we reckon in terms of 3 mg. per square centimetre per hour. If a laboratory test is conducted with these conditions and these amounts the order of results alters. I suggest that more attention should have been paid to the quantity of ash. I say that because I differ from the authors in respect of the effects of titanium and molybdenum in the alloys. I must be a little careful and say that I have not dealt with vanadium pentoxide alone. I have dealt with it in the presence of sodium oxide, which is always present in a fuel. In tests in which we estimated the rate of attack with varying proportions, we chose the most virulent proportions of sodium oxide to vanadium pentoxide. Under those circumstances we find that if an alloy contains titanium, as does Nimonic, the attack, again, is intercrystalline in nature since we find that sintered titanium carbide bonded with a small metal matrix is very badly attacked by vanadium pentoxide. It is one of the worst of the lot. I think it is reasonable to infer at least, if no more, that the presence of precipitants such as titanium carbide in the grain boundaries leads to the intergranular attack. Similarly with molybdenum. Our alloys were not as highly alloyed in cobalt as those discussed; they had 10 to 20 per cent chromium and 10 per cent cobalt. However, the attack was very catastrophic when molybdenum was present. This was probably because we were dealing with rather larger quantities of ash than are usually met with in practice.

Universal Pile Driver

THE accompanying illustration shows a 100ft, 7-ton pile driver designed and built in under four months by Woodfield Hoist and Associated Industries, Ltd., of Rochester, Kent. The machine, which was demonstrated recently at the maker's works, is intended for use in the reconstruction of the roadway between Hayling Island and the mainland, work which will involve piles 80ft long and weighing over 9 tons each. In order to minimise the amount of auxiliary timber staging required while working over the sea, the driver can be operated from the winch platform and is able to carry out all its manœuvres under its own power. In addition to operating the hammer, these comprise slewing through a full circle, backward and forward raking, and travelling on a rail track as well as assembly and dismantling.

The undercarriage runs on a track measuring



65ft pile driving frame with 100ft leader, for use with a 7-ton hammer. For transport the frame can be dismantled into sections not wider than 8ft

14ft 6in between rail centres. Its four wheels are driven from the winch through bevel gears, and on it the platform turns on twelve spider-mounted rollers, which are arranged inside the circular slewing rack. On the platform are mounted the winch and two 2000/3000 lb per hour, 120 lb per square inch boilers, one for operating the winch and the other for the hammer. The 65ft high superstructure is carried on two pivots at the front end, and is supported on each side by a bevel-driven raking screw.

The 100ft leader is hinged to the crown block by retractable pins. Its lower end slides in a block hinged to a horizontal extending strut at platform level, so that by raking the superstructure and adjusting the strut the leader can be set at the angle required. By engaging the crown block pins at different positions, the leader may be lowered to 24ft below the track.

The steam-operated winch is mounted on its own skid base on the platform and has two cylinders of 10in bore by 12in stroke. For normal working the machine is fully balanced and stabilised when necessary by using screw jacks.

East Yelland Power Station

As recorded briefly in last week's issue, East Yelland power station, between Barnstaple and Bideford, was officially opened on April 21st by the Earl Fortescue, Lord Lieutenant of Devon. The first half of the station is in commission, the main plant consisting of six 180 k lb per hour boilers, fired by chain grate stokers and supplying steam at 600 lb per square inch and 850 deg. Fah. to three 30MW, 3000 r.p.m. turbo-alternators. Circulating water is taken from the River Taw estuary.

EAST YELLAND power station is the first large coal-burning station in the Barnstaple-Bideford region which hitherto has been supplied with electricity mainly by diesel-driven generators. The new station, with its present installed capacity of 90MW (ultimately to be increased to 180MW), will, however, be able to meet much more than purely local needs. Approximately 25 per cent of the present output will supply the demands of North Devon, while the remainder will be transmitted to Taunton and Cornwall.

The station is sited on East Yelland Marsh, about halfway between Barnstable and Bideford. To the north and west the site is bounded by the River Taw and to the south by the main single line railway between Barnstaple and Bideford ; a turnout from this line serves the station with three marshalling sidings and branches to loading bays at each end of the turbine house and the 132kV substation.

East Yelland satisfies many of the basic requirements for a power station site. The foundations are on ground consisting mainly of sandstone, with some shale. Adequate cooling water is available from the estuary and coal can be shipped direct from South Wales to the station jetty, the main limitation being that the shallow water at Bideford Bar restricts the colliers to a carrying capacity of about 750 tons.

Proposals to build the power station on East Yelland Marsh were discussed by The Whitehall Securities Corporation, Ltd., in conjunction with the Central Electricity Board in 1946, and reports on the project were prepared by mid-1947. In September, 1949, the Minister of Fuel and Power gave consent to the building of the station, which, by that time, had become the responsibility of the British Electricity Authority (now the Central Electricity Authority).

Work on the main foundations was started in April, 1950. At the peak of the construction programme a labour force of 670 was employed and before the end of 1953 the first two 30MW generating sets were in commission. Three such sets, making up the first half of the station, were completed in 1954.

East Yelland power station is operated by the South Western Division of the Central Electricity Authority, but the design and constructional stages for the initial programmes was the responsibility of the headquarters staff of the authority under Mr. V. A. Pask, the chief engineer. In the subsequent programmes, Mr. A. C. Thirtle, controller of the South Western Division, and Mr. J. Irlam, generation engineer (construction), will be responsible for the construction work. For the whole of the programmes the consulting engineers are Messrs. Preece, Cardew and Rider, and the associated civil engineering consultants are Sir Alexander Gibb and Partners. The consulting engineers are responsible for the architecture of the station.

The main buildings (Fig. 1) are steel-framed structures with brick walls, r.c. roofs, floors and foundations. A reinforced concrete chimney handles the flue gases from the first half of the station. To satisfy Air Ministry requirements the chimney is at present limited to a height of 117ft 6in, but the design is such that the height can be increased to 214ft. A similar chimney will serve the second half of the station.

The circulating water inlets are integral with the jetty structure and are connected to the c.w. pump house by two 6ft diameter tunnels. From the pump house the circulating water is carried by a twin inlet r.c. culvert which is embodied in the foundations of the main building, crosses the boiler-house and splits to serve the two halves of the turbine house. An outlet culvert runs parallel with the inlet culvert in each half of the turbine house. At the centre of the station these two outlets are combined to form a twin outlet culvert to the outfall.

A sea wall with its crest about 18ft above O.D. protects the site from the estuary tide, which has a range from about −9ft to +17ft O.D. The coaling jetty, which is of reinforced concrete construction, is built roughly parallel with the sea wall and about 400ft from it.

The jetty consists of a 40ft wide cast-in-situ deck slab supported by two rows of piers consisting of r.c. tubes 4ft 6in internal diameter. A 17ft approach way carrying a 10ft wide roadway and the first section of the coal conveyor connects the jetty to the shore.

Colliers alongside the jetty are unloaded by 150-ton-per-hour telpher transporters (Fig. 2), which have hoppers arranged to feed a 300-ton-per-hour belt conveyor. The belt conveyor system takes the coal either direct to the bunkers over the boiler-house firing aisle or to the coal store to the north-east of the station building. Recovery from the store is effected by a drag scraper which feeds the coal, via hoppers, back to the main conveyor system. Automatic weighers measure the quantity of coal unloaded and the quantity delivered to the bunkers from the jetty or from stock.

To meet the ultimate coaling requirements a third telpher transporter and a second drag scraper will be installed with the second half of the station.

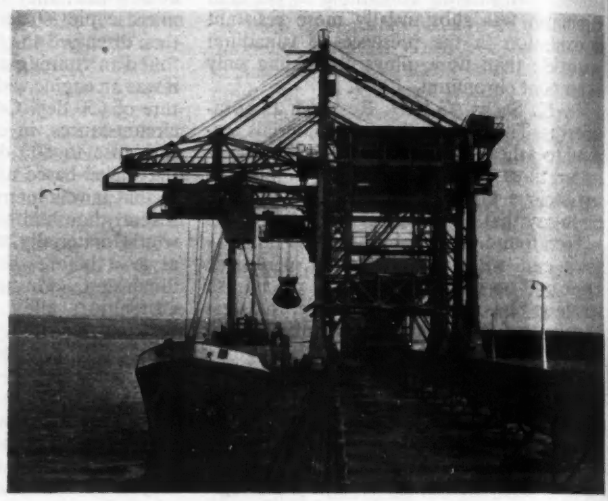


Fig. 2—Coaling jetty at East Yelland power station. Each of the two electrically operated telpher transporters has a handling capacity of 150 tons per hour

Six John Thompson boilers generating 180 k lb of steam per hour at 630 lb per square inch and 865 deg. Fah. serve the first half of the station ; five similar boilers will be installed with the second half. The boilers are fitted with chain

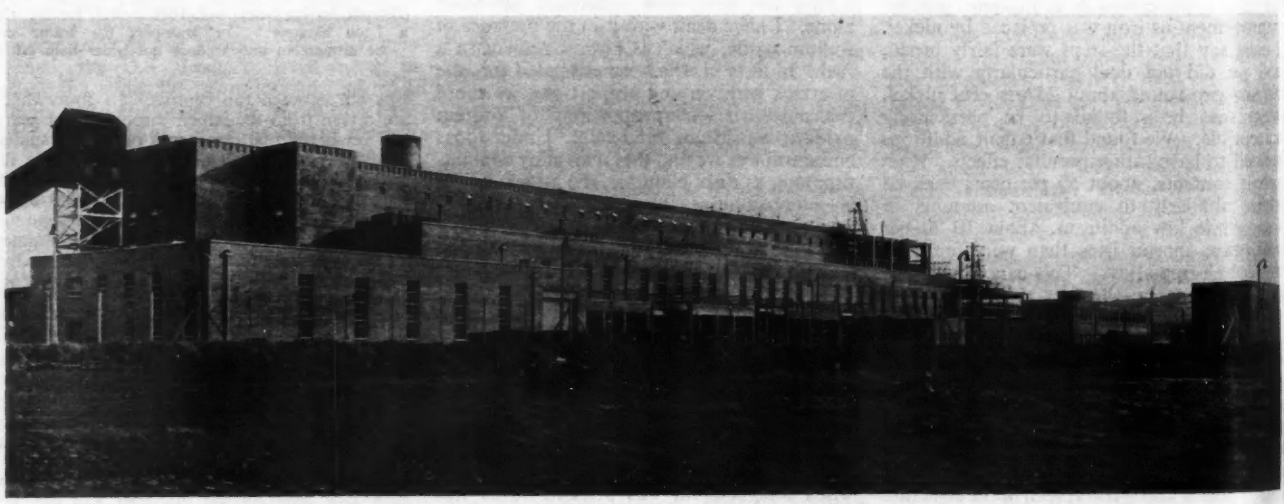


Fig. 1—East Yelland power station of the South Western Division, C.E.A. The station is between Barnstaple and Bideford and will have an ultimate capacity of six 30MW turbo-alternators, three of which are now installed

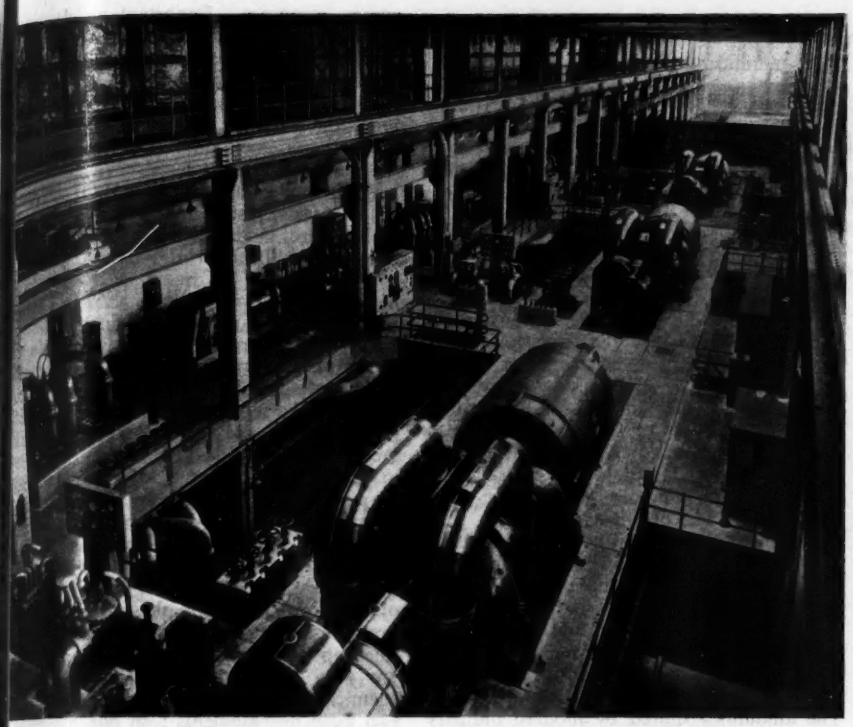


Fig. 3—Three 30MW turbo-alternators installed in East Yelland power station. The partly completed structure for the second half of the turbine house can be seen in the background

grate stokers fed from the bunkers by traversing chutes. Grit arresters are installed.

Combustion is hand controlled from a centralised system. Direct current motors fed from two 365kW Metropolitan-Vickers glass-bulb, mercury-arc rectifiers drive the stokers and f.d. and i.d. fans. To ensure optimum combustion conditions at any load, simultaneous control of these d.c. motors is exercised by grid control of the mercury arc rectifiers supplying the armature circuits with voltage variable from 0V to 550V, while the motor fields are supplied from constant voltage, 130V, busbars. This control is effected by a motor-driven phase shifter operated from the boiler gauge board. Automatic control of steam temperature is achieved through butterfly valves in the steam connection between the primary superheater outlet and the secondary superheater inlet headers. One feed pump electrically driven by a 450 h.p., 3·3kV squirrel-cage motor is installed for each boiler; in addition, for each half of the station there are two standby pumps—one electrically driven and the other steam-turbine driven. The latter exhausts to atmosphere and is designed to start automatically by a fall in pressure in the discharge main. The boilers and air heaters are fitted with automatic soot blowers.

Ash and dust disposal is by road. Ash and riddlings from the boiler grates are discharged to belt conveyors submerged in water troughs, one for each half of the station. From these two submerged conveyors the ash is discharged to an inclined open belt conveyor and then into a bunker from which lorries can be loaded. A vacuum system removes dust and grit from the boilers, economisers, grit collectors and chimneys and delivers them to collector tanks, where they are wetted for disposal, as convenient, in the ash handling lorries.

A market is found for about 75 per cent of these "waste" products in the manufacture of building materials.

When complete the station will contain six Parsons 30MW, 3000 r.p.m. turbo-alternators (Fig. 3), supplied with steam from eleven boilers, via six interconnected steam receivers in the station basement. The turbines are two-stage machines, the steam conditions being the standard 600 lb per square inch and 850 deg. Fah. with 29in vacuum. Four stages of bled steam feed give a final feed temperature of 345 deg. Fah.

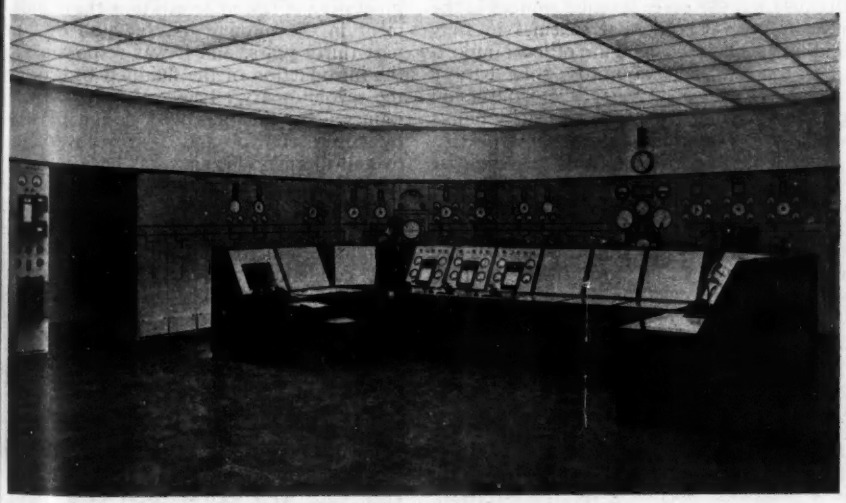


Fig. 4—Control room at East Yelland power station

The condensers are twin-shell, two-pass equipments, with fabricated bodies and cast iron water boxes, taking 28,000 gallons per minute of cooling water at the maximum continuous output of 30MW. Circulating water for each set is pumped by a vertical-spindle pump driven by a 525 h.p., 3·3kV, three-phase squirrel-cage motor. There are fixed screens at the intake under the jetty and four vertical travelling hand self-cleaning screens are installed in the pump house to remove seaweed and other debris. To prevent marine growths in the intake tunnels, culverts and condenser tubes the water is treated at a maximum rate of 10 parts of chlorine per million of water, by two automatic chlorinators, each designed to handle 82,000 gallons of sea water per minute.

Make-up water for the whole station is purified by three triple-effect evaporators, each of which takes mains water, suitably softened, and gives a net output of 25,000 lb per hour.

Each alternator generates its output at 11·8kV and is solidly connected to a main generator transformer. On two of these transformers the output is stepped up to 33kV and on the remaining four to 132kV.

The station control room for the turbo-alternators and outgoing feeders is illustrated herewith (Fig. 4). From the main generator transformers the 33kV cables are taken to the 33kV switch house adjoining the office block, while the 132kV cables are taken to the nearby 132kV outdoor substation. Supplies are taken from the 33kV switch house to two station transformers which step down the voltage to 3·3kV for feeding the station auxiliary board and the unit auxiliary boards associated with each turbo-alternator set. For the low-voltage auxiliaries the voltage is further transformed to 415V.

The main 132kV switchgear is B.T.H. outdoor bulk oil equipment with a rupturing capacity of 2500MVA. The 33kV switchgear consists of Ferguson-Pailin "VTLP10" oil-filled, indoor units with double busbars, vertical isolation and a short circuit rating of 750MVA. On the 132kV system the neutrals are solidly earthed. On the 33kV system the transformer neutrals are connected to an earthing mesh through single-pole oil circuit breakers. The mesh can be earthed either through an arc suppression coil or through a liquid earthing resistance. The neutral point of each alternator winding is earthed through a current-limiting liquid resistance.

Main Contractors

Civil engineering: access road, jetty and river works, Charles Brand and Son, Ltd.; foundations, Taylor Woodrow Construction, Ltd.; structural steelwork, John Lysaght's Bristol Works, Ltd.; superstructures, Staverton Builders, Ltd.; reinforced concrete chimney, Tileman and Co., Ltd.

Plant: jetty coal unloaders, Strachan and Henshaw, Ltd.; coal conveyors, Spencer (Melksham), Ltd.; boiler plant, John Thompson Water Tube Boilers, Ltd.; ash conveyors, the John Thompson Conveyor Co.; dust extraction plant, John Thompson Industrial Constructions, Ltd.; turbo-alternators and feed heating equipment, C. A. Parsons and Co., Ltd.; condensing plant, G. and J. Weir, Ltd.; h.p. pipework, C. A. Parsons and Co., Ltd.; central evaporating plant, Aiton and Co., Ltd.; l.p. pipework, Simmons and Hawker, Ltd.; water storage tanks, Horseley Bridge and Thos. Piggott, Ltd.; boiler feed pumps, G. and J. Weir, Ltd.; auxiliary pumps, Gwynnes Pumps, Ltd.; fire-protection equipment, Mather and Platt, Ltd., Fire Armour, Ltd.; air compressor, Ingersoll-Rand Company, Ltd.; turbine house crane, Clyde Crane and Engineering Company; auxiliary cranes, Wharton Crane and Hoist Co., Ltd., John Smith (Keighley), Ltd.; water softening plant, The Permutit Company, Ltd.; c.w. pumps, W. H. Allen, Sons and Co., Ltd.; c.w. pipework, William Press and Son, Ltd.; c.w. screens, F. W. Brackett and Co., Ltd.; chlorinating plant, Wallace and Tiernan, Ltd.; generator and interbus transformers, C. A. Parsons and Co., Ltd.; station and unit transformers, Brush Electrical Engineering Company, Ltd.; 132kV switchgear, British Thomson-Houston Company, Ltd.; 33kV switchgear and neutral gear, Ferguson Pailin, Ltd.; 3·3kV switchgear, Ferguson Pailin, Ltd.; 415V contactor gear, Contactor Switchgear, Ltd.; 415V distribution gear, A. Reyrolle and Co., Ltd.; station battery, Pritchett and Gold and E.P.S. Company, Ltd.; battery charger and d.c. switchboard, Hackbridge and Hewittic Electric Company, Ltd.; cabling, Aberdare Cables, Ltd., and Malcolm and Allan (London), Ltd.

Illustrated Book on Steel Structures.—A book containing illustrations of many recent structures—including schools and offices and heavy industrial buildings—erected by the United Steel Structural Company, Frodingham Works, Scunthorpe, Lincs, has been published by that company. Illustrations of the company's fabricating and stocking installations, and of various special kinds of construction—for instance, with tubes or "Castella" beams—are also shown.

Engineers' Contribution to the Conservation of Natural Resources

By SIR HAROLD HARTLEY, K.C.V.O., F.R.S.

Brief abstracts are reproduced here from the first Graham Clark lecture, which was delivered by Sir Harold Hartley at the Institution of Civil Engineers on May 4th. Mr. Graham Clark was for many years Secretary of the Institution of Civil Engineers. The lectures named after him are intended to be on subjects of common interest to the three major engineering institutions.

I SHALL interpret my title in the broadest sense to include all the engineering technologies as it is the intention of these lectures to commemorate the wide outlook of Graham Clark and his wish to see the Institutions co-operating on broad lines of policy. How am I to reconcile the idea of conservation with the steadily increasing consumption by the engineer of the world's natural resources ? Conservation is defined in the Oxford dictionary as " preservation from destructive influences, decay or waste." Leaving aside for the moment the raw materials which are the basis of all engineering production, let me ask what are the natural resources on which civilization has been built and which today are proving the limiting factors both in development and in supplying the world's food, its most crying need ? The answer is soil and water. It is here from the earliest times that the engineer has made his basic contribution to the conservation of resources, and the material future of the world is so largely dependent on his continuous success in this field.

Water and the Irrigation Engineer

Water I put first as it is essential to all forms of life and industry, the indispensable resource on which plans so often have to be based, and its conservation has the highest priority. Without it soil becomes a desert, production an impossibility ; but water is also a potent source of destruction and a carrier of disease, so the engineer has here a dual task. Thanks to the sun's radiation there is a continuous cycle of evaporation and rainfall, 98 per cent of the earth's water is in the sea, 98 per cent of the rest is frozen in the polar ice caps, only 0·04 per cent of the water is in the rivers and lakes, and only one part in 100,000 in the hydrologic cycle in the atmosphere on which life depends. The formation of soil is dependent on the weathering action of water and ice on the rocks, some soils are wind-blown, but most are formed by waterborne alluvium.

The advent of hydro-electric power and the advance in engineering techniques have made possible the multi-purpose schemes for water control with their objectives of flood control, power supply, irrigation and transport.

The present land area in the world cultivated for food is about 1620 million acres and of this 230 million acres are under irrigation, much of it perennial, and these acres are of special value as they grow more than one crop a year under semi-tropical conditions. It may be possible to double this irrigated area in places where water is the limiting factor in cultivation, as in India, for example, where only six per cent of the river flow is used in this way. Spraying is a much more efficient use of water than surface distribution as it can be controlled and the right amount of water applied when it is most needed. Much progress has been made with spraying in Arizona where water is precious and where the cost of the equipment is outweighed by the increased crop yields.

But irrigation is another interference with nature and the engineer's task is not finished when he has provided the irrigation water, since it brings with it the danger of salinity and alkaline soils which is now threatening large areas in the Punjab. All irrigation water contains some salt which is also present in the soil and unless there is efficient natural or artificial drainage the salt will accumulate and the soils may become alkaline with the loss of soil structure.

In some places water is becoming the limiting factor to the development of cities and of industry and in Britain it is already difficult to locate a new industry needing much clean water or to find inland sites with cooling water for power stations and industry. Nuclear power stations will almost certainly be sited on the coast for this reason. The amounts required by modern industry are large—a million gallons to make a ton of viscose yarn, and 400,000 gallons a ton of steel. Here the engineer can help by the efficient treatment of effluents and sewage, by the reuse of water by means of cooling towers, or by returning well water used for cooling to the strata from which it was drawn. Even in Britain water is needed for irrigation south of a line from the Severn to the Humber if maximum crop yields are to be obtained.

Energy

Next to soil and water I rank energy as the third great need of mankind, since statistics show that the consumption of energy per capita determines the standard of living of a country. Here the engineer by the increasing use of water power is drawing on revenue and not on a capital resource, though water power only provides 4 to 5 per cent of the world's energy consumption. Other revenue resources are solar radiation, wind, tidal energy, geothermal heat and the burning of timber and vegetable products. The latter source provides some 18 per cent of the total energy consumption to-day, and there is not much prospect of any considerable contribution from the other revenue sources in the near future. Geothermal schemes in Italy and now in New Zealand are of local importance, and the Bell Laboratory solar battery with a 10 per cent efficiency of conversion of solar radiation energy to electricity points the way to important developments.

The main contribution of the engineer hitherto has been the steady rise in the efficiency of combustion appliances, in the generation of electricity and in the gasification of coal. In the United Kingdom the increased demands for energy between 1920 and 1937 were met almost entirely by increased efficiency of energy conversion and utilisation representing a saving of at least 40,000,000 tons of coal. There is no need to stress the importance of a continued effort for higher efficiency, but fortunately the possibilities of the nuclear power station have come just when there is little prospect of large additions to the output of coal. Here again is a combined operation for the electrical, chemical, mechanical and civil engineer which will add a hundredfold to the world's energy resources. Important as electricity is as a source of heat and power, our economy is linked in many ways with liquid fuel, and the coming of nuclear power will enable the coal and oil resources to be used in the future more and more as a source of chemicals and of the liquid fuels on which for many purposes our economy is based. We shall watch with envious eyes the great SASOL plant in South Africa, just coming into operation to make petrol and other products from the cheapest coal in the world.

Extractive Metallurgy

We are living in a metal civilisation and in spite of the progress that is being made in the use of plastics and bonded materials as substitutes, we must look to an increasing use of metals in the future. For many engineering purposes they are indispensable, and progress in metallurgy is often the limiting factor in engineering design. All recent surveys of resources like the Paley report make it clear that we shall become increasingly dependent on lower-grade ores, often containing several finely intergrown minerals which must be separated. For the treatment of such ores the older physical methods of ore dressing producing concentrates for smelting are proving inadequate and they are now being supplemented by various chemical engineering techniques. There are two main developments : in one the metals are leached out by various solvents, sometimes under pressure, and are then separated by different methods, precipitation, electrolysis, or solvent extraction, as in the case of uranium. For example, a large ore deposit containing less than 1 per cent of copper oxide is being leached with sulphuric acid. Bacterial oxidation of a low-grade, partly oxidised copper sulphide deposit is being tried with the same object. Nickel sulphide concentrates are being leached with aqueous ammonia and oxygen under pressure.

The other method consists in treating ores in fluidised beds at controlled temperatures with various gases. Iron oxide can be converted to magnetite for magnetic extraction, and sulphide of copper, nickel and cobalt can be roasted to sulphates for subsequent leaching with water. By temperature control an almost complete separation of copper from iron can be effected in this way. A number of methods are being investigated for the extraction of manganese from low-grade ores and open-hearth slags.

Processing Raw and Synthetic Materials

There is no better example of the great advances that have been made in the scientific processing of raw materials than the improvement in the refining of crude oil over the past thirty years, and it was responsible for the introduction of the fluidised bed, one of the revolutionary advances in modern techniques. By the improved design of stills, by better control and heat recovery, the overall thermal efficiency has been raised by 25 per cent, the amount of refinery fuel required being less than 2 per cent of the crude oil distilled. Then the amount of motor gasoline produced to-day by thermal reforming, catalytic cracking, polymerisation of olefines and other new techniques is on a world basis 36 per cent by weight of the crude as compared with 18 per cent by straight distillation thirty years ago, and the octane number of the gasoline is much higher with the resulting improvement in fuel economy.

Further, there has been a great increase in the range of products and their quality to keep pace with technological progress, for instance, in the development of aero engines. Synthetic detergents, paint additives, cutting

oils and an immense range of lubricants are among the most significant advances. Propane and butane are sold as "bottled gas" instead of being burnt as refinery fuel. A new aliphatic chemical industry has been based on refinery gases, and platforming adds largely to the supply of aromatic chemicals like benzene, which are now in such great demand.

There are many other parallel examples of this trend of modern industry to make better use of its new materials—rubber, cellulose, leather and, above all, perhaps in importance the scientific processing of food, which is now a great industry which contributes so much to its preservation and economy.

Synthetics in the twentieth century have done much to change the pattern of our life and synthetic ammonia has relieved our anxiety about nitrogen fertilisers, which by increasing the output per acre, are a most effective means of conservation. Plastics and synthetic fibres not only supply many new needs, but as substitutes for vegetable products they relieve the demand for them and thus leave more soil for food production. The output of rayon and viscose already exceeds that of wool.

But man's power to synthesise materials economically is limited to simple molecules and their polymers. There is no hope of his manufacturing the complex proteins and polysaccharides he needs for food without the aid of living organisms, who make them so accurately and cleanly by their template methods. Fermentation is one of the oldest industries but it is only in this century that microbiology has revealed the almost unlimited possibilities of the living cell. From Pasteur and Koch the microbe got a bad name, but without it life on this planet could not exist. The microbe is a great conservationist and it deserves a better reputation. The amount of nitrogen supplied to the soil each year by fertilisers is only a small fraction of that fixed by living organisms in the soil.

Rahn, in a comparable study of the criminology of the microbe and mankind in the United States, concluded that only one micro-organism in 30,000 was a carrier of disease, while in the year of his census one inhabitant in 17,000 was convicted of murder. And as Professor Kluyver pointed out in his Leeuwenhoek Lecture, the amount of microbial protoplasm in the world is probably twenty times as great as that of animal protoplasms, so there is no lack of ready helpers with an amazing adaptability. The harnessing of micro-organisms in the production line in friendly tasks is one of the great ventures of the near future—biochemical engineering.

The Conservation of Human Labour

I have left to the last the engineer's conservation of human effort, both manual and mental, by mechanisation, automatic control and electronic computers. In the race for productivity mechanisation is the pacemaker. Recent figures from the United States show that the productivity per head has doubled with the doubling of the horsepower employed. And now a new factor is coming in, as automatic control not only replaces manpower and accelerates production but its products are of higher quality. Electronic devices are much quicker and more accurate than the human brain and can be used for an infinite variety of control purposes. And whereas the human senses can only deal with one operation at a time, an electronic system can regulate simultaneously the many interlocking controls required in a large plant. The nation-wide automatic dialling system of telephones in the United States is a good example. Then analogue computers can simulate complex operating problems and provide a short cut to the answer, digital computers can solve in a few minutes differential equations which would otherwise require a prohibitive number of man hours of work.

There is no need to dwell on the contribution of mechanisation to the economies of the production line. Automatic control is another story. On the one hand, great progress has been made in the mathematical theory of control design which is directly applicable to the design of control equipment for systems in which the dynamic characteristics of the mechanisms are known. On the other hand, progress in instrumentation and in the technique of servo-mechanisms has led to the widespread application of automatic control to machines and continuous processes which were not originally designed with this in view. If the maximum advantage is to be made of this new approach, its philosophy and theory must start in the design phase and be applied continuously. This entails both an appreciation by the designer of its possibilities and the co-operation with him at each stage of the control engineer who has specialised in control theory and instrumentation. A big educational problem is involved which is vital to the industrial future of this country, especially now that full employment has been reached.

Information from the United States and the Soviet Union is strong evidence of the much greater awareness of the urgency of this problem in both those countries. In the United States there are said to be close on 2500 companies in the control business employing 8000 graduate engineers who have specialised in this field, and there are 15,000 more in the user industries. Russia has concentrated her mathematical ability on the theory of automatic control and her numerous applications of it in industry show how effectively she has grasped its philosophy. She was operating in 1951 the first complete automatic production line of an aluminium alloy piston from the ingot to the finished product fully tested and examined, and she had automatic plants making cylinder blocks in 1948 and also agricultural machinery. Her automatic tests of surface finish are most effective and ingenious. Evidently her objective is high quality machine production using a minimum of skilled personnel, thereby increasing her competitive position with the other great industrial powers of the world. This is the Russian engineer's contribution to conservation.

I do not wish to end this review of the engineer's achievements on a gloomy note so far as Britain is concerned, but I must draw attention to the urgent need for a more active recognition of the future importance of control engineering.

Two-Spindle Automatic Chucking Machine

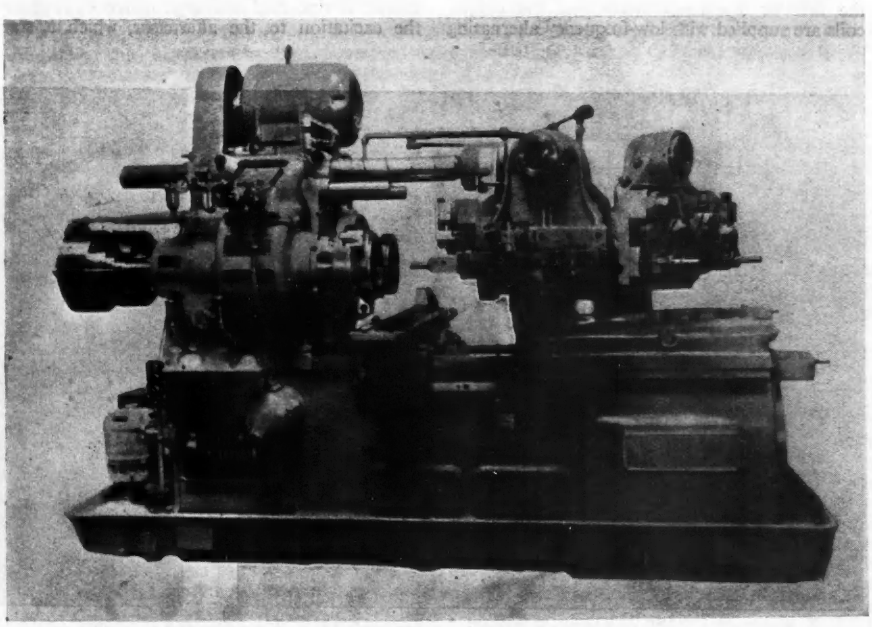
Some particulars have been received from Burton, Griffiths and Co., Ltd., Kitts Green, Birmingham, 33, of a new Potter and Johnston two-spindle "5D 2–15" automatic chucking machine, which is illustrated on this page.

The all-geared headstock of this machine is driven through multiple vee belts by a 15 h.p. motor and the two spindles are set at 15½in centres. Work up to 28in diameter can be swung over the bed and 18in diameter over the cross slide. Twenty-eight spindle speeds from 16 to 525 r.p.m. are arranged in four ranges selected through pick-off gears located in a compartment at the end of the headstock. The spindles are bored 1 13/16in diameter and can be supplied fitted with either air, hydraulic or electrically operated 15in diameter chucks. Twenty-four feeds ranging from 0·0057in to 0·125in are arranged in three groups and a feed rate from each group can be selected through pick-off gears in the feed box.

Indexing of the five-station turret is by a Geneva revolving mechanism and, after indexing, the turret is automatically clamped in position. The turret is provided with two centre positions on each face for the fitting of tools which are in line with the axes of the two spindles.

This arrangement enables operations to be performed on two workpieces simultaneously, or to handle one operation on one workpiece and perform supplementary work on another workpiece at the same time.

The turret slide has a travel of 16in and its position can be adjusted along the bed to vary the distance between the spindle noses and the turret faces from 15in to 24in. The cross slide cam drum is located beneath the slide in a compartment at the rear, outside the base ways, and it is driven through worm gearing. The cross slide itself is adjustable along the bed and its feed movements can be timed to operate during turret dwell periods.



Automatic chucking machine set up for two machining operations on flywheels

Induction Heating of Ingots for a Steel Rolling Mill

The first commercial plant for the induction heating of ingots for a steel rolling mill is described here. It is owned by Western Canada Steel, Ltd., and is operated by that company's rolling mills in Vancouver. Heating takes place by induction in two parallel tunnel furnaces through which the ingots are fed. The low-temperature zone is energised at 60 c/s and the hot zone at 540 c/s. Compared with the previous oil-fired furnaces the new installation is said to show 75 per cent reduction in heating time, 30 per cent increase in production and a saving of a dollar per ton in fuel or energy costs.

THE induction heating of ingots for a steel rolling mill has been applied for the first time as a commercial process at the Vancouver rolling mills of Western Canada Steel, Ltd., from whom brief details of this interesting development have reached us. Experience with the new installation since it started operation some ten months ago indicates that the time for heating ingots has been reduced by 75 per cent, production has been increased by 30 per cent, and fuel costs have been reduced by one dollar a ton, or about 100 dollars per shift. The finishing capacity of the plant has been increased from 40,000 tons to 70,000 tons per annum.

The heating plant consists essentially of two identical tunnel induction furnaces arranged in parallel. Cold ingots are fed into one end of each tunnel and the hot ingots at the discharge end are fed to separate roller conveyors which are then united to provide a single feed to the first mill.

Fork lift trucks and conveyor belts are used to bring the ingots from stock piles in the yard, to the feed trough where they are deposited, as required, one at a time. Hydraulic rams push the ingots from the feed troughs into one or other of the heating tunnels. The line of ingots is continuous, so that, as one ingot is being pushed into the feed end, a hot ingot is emerging from the discharge end. Interlocks keep the two lines in step, so that ingots are fed to the mill at regular intervals. By having two tunnels in parallel it was possible to keep down the overall length of the installation. This arrangement also gives some flexibility in operation, since each tunnel can be worked independently.

The induction heating chamber consists of a series of large current-carrying copper coils set in (and insulated from) refractory blocks placed end to end to form a tunnel through which the ingots are fed, becoming heated by electromagnetic induction as they travel from one end to the other.

Each tunnel is divided into two portions. In the first or low-temperature zone the copper coils are supplied with low-frequency alternating current at 60 c/s. In the second or high-temperature zone a frequency of 540 c/s is used, the power being supplied from a 5000kVA motor generator set. The coils are insulated with glass tape and silicon varnish, and cast in a refractory of high density and strength. This cast housing prevents the vibration of the coil from breaking down its insulation. Initially, the coils were constructed with 310 stainless steel liners, but the insulation packed between the coil and the liner broke down after eight to nine operational shifts ; it was found that the severe vibration of the ingot had resulted in the liner abrading the insulation, causing a short circuit between turns. Accordingly, these stainless liners were, in the main, discarded, and replaced with high-silicon ceramic liners, which were bonded to the coil and held immobile by the castable refractory.

Power for the induction furnaces is derived from a spur connection to the 60kV ring main of the B.C. Electric Company, Ltd. This supply is stepped down from 60kV to 4kV by three 3000kVA water-cooled transformers and is connected to a 5000kVA synchronous motor, which drives a 3500kW, unity power factor alternator running at 720 r.p.m. and generating at 540 c/s, 400V. The synchronous motor is started by an auxiliary slipring motor with automatic synchronisation and a clutch to disconnect the slipring motor after synchronisation. The 60 c/s supply is taken from a 4000kVA, three-phase transformer, with off-load tap-changing, stepping down to 550V.

The 540 c/s current is fed to the induction coils by multiple cables with phases interleaved, the cables being supported by wooden clamps in aluminium ducts. The 540 c/s induction heating coils are divided into two groups on each phase and the main cabling from the generator is split to feed each group of coils. No switching is done on the 540 c/s supply, and protection is obtained by overcurrent relays and balanced split-phase protection of the generator windings. Auxiliary contacts on these relays operate the contactor type field discharge switch controlling the excitation to the alternator, which is star connected, the star point being earthed, as is the return lead from each of the induction coils.

Control of the heat input to the induction coils is effected through a motor-operated field rheostat whereby the alternator output can be varied. Input to the furnaces is measured by wattmeters and watt-hour meters. Individual ammeters are installed to indicate the current taken by each coil group and to show, separately, the total alternator current per phase.

The 60 c/s power is controlled by six circuit breakers feeding two groups of induction coils in each phase. The 4000kVA transformer supplying this energy is star connected, and the returns from each coil are connected to the star point, which is also earthed. An investigation into the earthing conditions indicated that an earth mat with sixteen 8ft rods spaced approximately 8ft apart would give an earth resistance of approximately a half ohm and this estimate proved to be correct.

Power factor correction of the induction heating coils is a major consideration and capacitors are connected in groups to each coil group of both frequencies. The correction required varies in the different coil groups with the temperature of the billets passing through the heating coils. Initially, the inductance was higher at the cold section of the furnace, and adjustments were made from experience to secure the optimum power factor conditions. The capacitors for the 540 c/s coils are water cooled. The average power factor throughout is stated to be better than 90 per cent, and approaches unity under most conditions. It is, however, subject to variations depending upon the sizes of ingots fed through the coils.

Cooling water for the 60 c/s and 540 c/s coils, the capacitors, the 3000kVA transformers and 540 c/s alternator, is supplied from a multi-baffle cooling tower at a rate of 500 U.S. gallons per minute.

An operator's control "pulpit" is arranged above the two flow lines, so that he has a good view of both ends of the furnace and of the mills. The control panel includes radiation pyrometers for indicating the temperature of the steel at the end of the 60 c/s section, the centre of the 540 c/s section, and at the discharge point. The operator also has control of the rate of feed and power input, as well as on/off controls for all parts of the installation. Finally, he has control of a power-driven roller conveyor, which extends from the furnace to the mill, and a gate provided in this conveyor, which allows him to direct ingots to the mill, or to set them aside. The furnace installation is operated by four men per shift.

With the larger ingots the average power consumption is said to be 300kWh per ton, or better, including all losses. With the smaller ingots, the average consumption is higher and

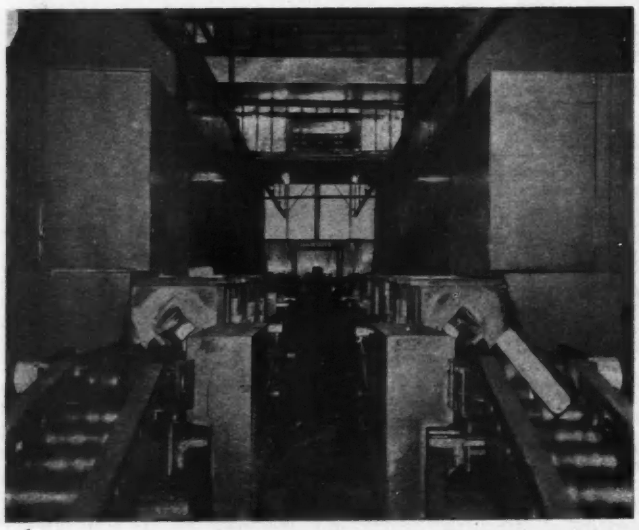


Fig. 1—Discharge ends of the induction heating furnace tunnels at the Vancouver rolling mills of Western Canada Steel Limited

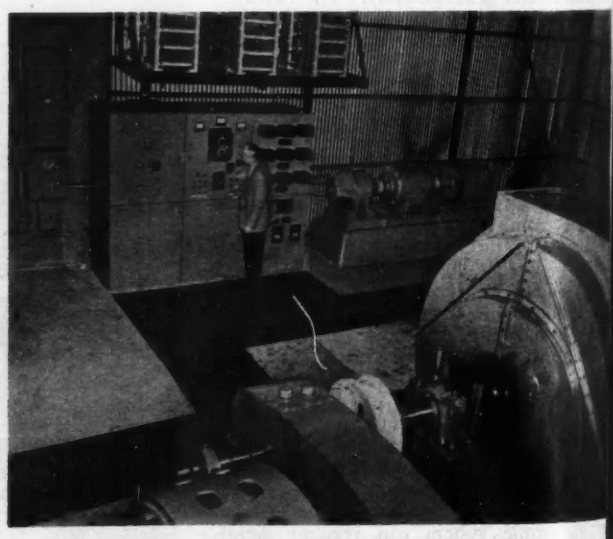


Fig. 2—5000kVA motor-generator set for supplying current to the high-frequency zones of the two induction furnace tunnels

the output is somewhat lower, as indicated in the accompanying table.

Size of ingot (inches)	Heating time (minutes)	Output (tons per hour)
4 by 4 by 36...	3·6	15
4 by 4 by 42...	4·25	15
5½ by 5½ by 43	4·75	20
5½ by 5½ by 45	5·0	20
5½ by 5½ by 56	5·5	20
6½ by 6½ by 49	8·4	20

The speed of operation is indicated by the fact that the total heating times range from 3·6 minutes to 8·4 minutes as also shown in the table.

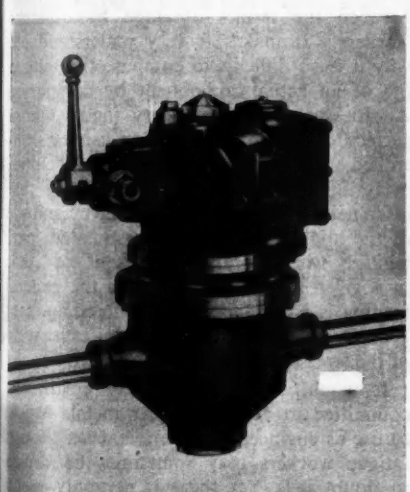
The furnace plant described here was built by the General Engineering Company, Ltd., Toronto. Design work was started in November, 1953, and the equipment was in full production in July, 1954. By March last it had heated more than 30,000 tons of ingots.

In the design and installation work the Vancouver Rolling Mills Division of Western Canada Steel, Ltd., was assisted by Professor W. Armstrong, consultant, the Electric Power Equipment Company, Ltd., Vancouver, and the Canadian General Electric Company, Ltd., who designed the alternator in the company's Peterborough works. This article is based on information provided by Mr. M. C. D. Hobbs, general superintendent of Western Canada Steel, Ltd.

Portable Pneumatic Tube Expanding Machines

THREE portable pneumatic tube expanding machines for light, medium and heavy duty, respectively, are now being made by the Globe Pneumatic Engineering Company, Ltd., High Road, Chadwell Heath, Romford, Essex. The heavy duty machine, illustrated below, is intended for such work as expanding the tubes in the steam drums of large water-tube boilers and is known as the "14 T.E." model.

The motor of this machine has four case-hardened pistons running in honed bores, and develops 1½ h.p. when supplied with air at 90 lb



Heavy duty portable pneumatic tube expanding machine

per square inch. A ball bearing mounted, two-throw crankshaft has two connecting-rods on each throw and the whole rotating assembly is balanced. Air distribution to the cylinders is controlled by two "Corless" oscillating valves driven by a double-step eccentric keyed to the crankshaft, and these valves operate in liners which can be rotated to obtain correct timing. A three stage gearbox driven from the motor incorporates a straight spur reduction and two single stage epicyclic trains. The output shaft is driven at 20 r.p.m. and has a 1in square socket to take expander mandrels; alternatively stub shafts can be provided to carry separate squared chucks. Any of a number of different throttle valves, including one of twist grip design, can be supplied with the machine. The overall weight of the machine is 70 lb. A ½ h.p. machine has a lock torque of 80 lb-ft. A larger machine rotates at 100 r.p.m. and has a lock torque of 120 lb-ft.

Modernisation Plan for British Railways

DETAILS of the main projects of improvement to be started in the next two years in connection with the modernisation plans for British Railways were announced last week by the British Transport Commission. In giving particulars of the projected work, it was pointed out by the Commission that the programme must be regarded as tentative so far as 1956 was concerned, and that it would be amended and enlarged as circumstances permitted.

It was stated that the track and signalling programmes being introduced will provide for additional bridge renewals, and for the improvement or strengthening of the track at various places in order to prepare for higher speeds and more punctual running; meanwhile the authorised renewal programmes, including in 1955 the complete renewal of 1800 track miles, will cover ordinary maintenance requirements. In the Eastern Region the four-tracking between New Barnet and Potters Bar, involving the construction of three new tunnels at a cost of nearly £2,750,000, is expected to start in 1955. This scheme will remove a long-standing bottle-neck on the East Coast route to Scotland; it is also a prerequisite of the electrification scheme for this line, which is included in the plan.

Additional schemes for the introduction of colour-light signalling, and the concentration of signalboxes, to be put in hand in the next two years at a number of places, will cost over £600,000. Other signalling developments which may be introduced in this period will total over £500,000. These developments will enable a reduction in the number of signalboxes and make possible more efficient operation, particularly in foggy weather. Improvements in telecommunications at various places will cost £325,000.

MULTIPLE-UNIT DIESEL TRAINS

One of the biggest items in the 1955-56 programme will be the provision of 1000 vehicles for the further replacement of steam passenger services by multiple-unit diesel trains. In this connection the following areas will be concerned: Edinburgh–Glasgow (express diesel services); Birmingham–Swansea (express diesel services); London–Hastings (express diesel services); East Anglia; Lincolnshire; Newcastle–Carlisle; Newcastle–Sunderland–Middlesbrough; Manchester (services radiating from London Road Station); North Wales (Llandudno–Blaenau Ffestiniog and Gaerwen–Amlwch); Birmingham–Lichfield; Birmingham (local and suburban); and the Hampshire Area.

Of these schemes for the introduction of multiple unit diesel trains that, covering the routes radiating from Manchester (London Road), in the area bounded by Crewe, Stafford and Buxton, is one of the largest yet planned by British Railways for any one area. It will require 168 motor-units and 116 trailers at an estimated cost of over £3,500,000, and will greatly improve the service to the public by an increase in train mileage of 38 per cent.

Another important scheme is that for the complete diesel train operation of the passenger service between Birmingham (New Street) and Lichfield (City), which will cost over £350,000. It will provide a much better service, with an increase in train mileage of 66 per cent.

MAIN LINE LOCOMOTIVES

Over the period of the plan some 2500 main line diesel locomotives are to be built and it is pointed out that locomotives of this class at present in use on British Railways are of several types and to some extent of experimental design. Before it is finally decided which types of diesel locomotives will be ordered in numbers, a pilot scheme will be brought into operation under which extensive trials can be made. The Commission has therefore approved the introduction of 170 new main line diesel locomotives for these trials. These locomotives will be of three main types: type A of 600–800 h.p.; type B of 1000–1250 h.p.; and type C of 2000 h.p. or over, for the heaviest duties.

The specifications for these locomotives provide for up to three locomotives of types A and B to be worked together as a multiple-unit if required, and two locomotives of type C. We understand that eleven of the trial locomotives will be diesel-hydraulic and the remainder diesel electric.

The replacement of all steam shunting locomotives by diesels will be continued, and it is expected 150 will be placed in service in 1955, and 200 in 1956.

ELECTRIFICATION

Extension of the Liverpool Street-Shenfield electrification to Chelmsford and Southend (Victoria), which is due to be completed by the end of 1956 at a cost of £2,500,000, will form the basis of further electrification along the Eastern Region main line to Ipswich, Clacton, &c.

Work on the associated scheme from Fenchurch Street to Tilbury and Southend is not so far advanced as extensive preliminary engineering works are involved before a start can be made with the actual electrification. It is, however, expected that good progress will be made with these preliminary works, of which perhaps the most important are the reconstruction of Barking Station, the rearrangement of the running lines in the neighbourhood, with the provision of "flyover" junctions, and new freight facilities. The scheme for the construction of the Barking "flyover" and the rearrangement of the track layout is estimated to cost £1,500,000, and will be started next year.

Preliminary planning work is being put in hand in the Eastern Region on the suburban electrification from Liverpool Street to Enfield and Chingford, Hertford and Bishop's Stortford, and also on the scheme for the former Great Northern section. Preliminary work is also expected to start on the extension of the Southern Region electrification over the remaining steam-operated main lines in Kent. In the London Midland Region, first steps will be taken towards the preparation of the main line electrification scheme from Euston to Birmingham, Liverpool and Manchester.

MARSHALLING YARDS, &C.

Work on the marshalling yard at Ripple Lane near Barking, estimated to cost £1,800,000, should start next year, and work is just beginning on the new marshalling yard at Temple Mills (Stratford), which will cost over £2,500,000. It is also likely that a start will be made with a large marshalling yard at Colwick, which is to cost £1,750,000.

A yard at Alloa, to be built at a cost of nearly £500,000, will deal with the coal traffic from the new pits in the Fife area, and another yard at Millerhill, near Edinburgh (to cost nearly £3,000,000) has been authorised. A new Yard at Port Talbot, to cost £1,500,000, will also be put in hand, as well as two others at Perth and Craiglockhart, which will cost together over £1,500,000.

The plan also contemplates a widespread rebuilding of some fifteen out-of-date passenger stations, and the construction of some new goods depots and improvements to others

NEW PASSENGER ROLLING-STOCK

About 4700 new passenger vehicles, including the diesel passenger coaches already mentioned, will be brought into service during 1955 and 1956. Although progress towards the standardisation of the 24½-ton wagon for mineral traffic must be governed by the rate of adaptation of terminal facilities, £1,000,000 will be spent in the next two years on building wagons of the new type. Provision is being made for the fitting of continuous brakes on new wagons and over £3,000,000 will be spent on this work in the next two years. About 66,000 new freight vehicles will be built for British Railways in 1955, and nearly 70,000 in 1956.

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FATIGUE

Nearly a century ago there began a series of failures to the early iron railway bridges in this country, and a committee was formed to establish whether metal was in fact a safe building material! It may have been thought at first that metals simply aged with time. But after four specimen beams had been loaded almost to breaking point for four years and not one had broken, that idea had to be discarded. The cause of failures became apparent only when repeated loading was applied. It was then revealed disconcertingly how much less was the load a beam could endure under those conditions. Thus, did engineers first become acquainted with fatigue in metals. How grimly it has since harassed them! There can be attributed to its ravages alone (or as often in subtle collaboration with corrosion) some 90 per cent of all failures. In early days its influence was disguised because high factors of safety could be accommodated without embarrassment in engineering structures and in the heavy steam and gas engines of the period which trundled over at less than 100 r.p.m. But to-day, perforce, many engineers worship at the altar of specific weight, traditional conservatism has had to be abandoned, factors of safety have come down and the visitations of fatigue failure fall prematurely and not without frequency upon shaft, piston and joint, in the power-house on the road, at sea and even in the air. It is, of course, in the air, whose craft are so utterly dependent on structural integrity for safety, where the consequences of fatigue failure are felt most acutely. Uncertain dynamic loading and indeterminate stresses are common in all engineering structures. But in aircraft they are uneasily combined with demands for lightness in structure and engine beyond the needs of all other spheres of engineering. Yet how pitifully little we know about fatigue! It is indeed a confession of ignorance that in this country—a land which ever since August Wohler's pioneering work has contributed particularly handsomely to knowledge of fatigue—we can find no better nor less expensive method than to blow up and load up complete aircraft to determine whether they are safe to fly.

In many engineering fields, the life of primary components is undetermined or uncertain. Experience rather than exact calculation determines safe scantlings. That is sad testimony to the consequences of 100 years of fatigue research work. Yet it is not very surprising. A perusal of the somewhat scanty literature readily available suggests how exceedingly complex the basic mechanism of fatigue really is. Perhaps that very complexity accounts for complaints made by various workers at the fatigue symposium held in Australia in 1946 about the lack of a sufficiently organised and co-ordinated investigation of the mechanism. It may account, too, for the complaint of the contributors of a paper from the R.A.E. about the indifference shown by designers to what has already been unravelled. The announcement of which we gave details last week of the symposium on fatigue to be held at the "Mechanicals" next year* will provide an urgently needed airing of what is being done, what remains to be done, and how it is planned to be done. That symposium will no doubt put into a proper perspective the different and sometimes wildly different theories propounded up to recent times to account for the mechanism of fatigue. It is now widely accepted that stress much below the fatigue limit causes plastic yielding by deformation across slip planes in the atomic space lattice of individual crystals. This phenomenon occurs under both static and dynamic loading, but to an extent dependent on the magnitude of the stress and the nature of the loading. The mind must therefore dwell upon nothing more than the almost infinite smallness of atomic geometry if the mechanism of failure is to be properly comprehended and the potency of minute metallurgical imperfections is to be appreciated. Below the fatigue limit this process of slipping under cyclical loading appears beneficent, somehow or other leading to what is termed "work hardening." Progressive deformation ceases and it matters not how many times the loading is applied. But above that level and with all higher stresses, deformation does become progressive, and, for some apparently unknown reason, a crack appears leading to the ultimate failure of the crystal after a finite number of load applications. The ugly cycle of fatigue failure has then commenced; the crack itself acts like a minute notch to induce a local stress concentration which ensures its propagation; the imposed stress probably increases as the crack advances, and all the time, as the unaffected area of the specimen diminishes, the mean distributed stress increases. This is the apparent process whether one considers the failure of a single crystal, a group of crystals or a crankshaft, for though crystal boundaries can exercise a restraining influence they are by no means impenetrable, nor do they necessarily divert a crack. Finally, when it is considered that this whole cycle can be triggered off by a local stress raiser of much less proportions than a scribing mark, a grinding mark, or a centre pop, a measure of the true subtlety of fatigue failure under dynamic loading begins to assert itself. The minute order of imperfection sufficient to induce a crack no doubt accounts, in some measure, for the lack of correlation repeatedly observed between different specimens and between the results obtained by different workers. It makes it very understandable why it is so difficult to compute the fatigue life of an actual component by comparing it with that of a laboratory model whose surface condition and loading can be controlled and simplified. The further difficulties occur in actual engineering structures that often neither the frequency nor the magnitude of the applied loads can be estimated, particularly when vibration is present, and that in a given structure, even when the general loading is accurately known, the component geometry may well prevent an estimation of the stresses arising at critical sections.

It would be no use to-day creating a committee to decide whether metals are fit to use as engineering materials, even though fatigue workers may sometimes be driven to doubt it! Yet there is certainly much which could profitably be reviewed at the forthcoming symposium. In how many universities, for instance, do students still labour on often out-of-date strain and stress measuring apparatus to produce a "verification" of Hooke's Law; to "prove" the existence of now highly suspect specific yield points; or to familiarise themselves with the classical mathematics of stress and load distribution based on the false premise of homogeneity and isotropy of metals? Perhaps they should continue to do those things. But is it brought home to them that radical and dangerous simplifications are involved? For workers in the field of fatigue over many years have struggled to emphasise that metals are not homogeneous and neatly oriented mats of fibrous elastic material. They are an untidy conglomeration of crystals

* In our last week's announcement we inadvertently referred to the symposium as being held in 1955, instead of 1956.

which even within themselves are not isotropic, but have entirely different characteristics across atomic planes. One wonders, judging by the constant recurrence of fatigue failures due to now well-recognised design faults, as noted by most investigators, whether engineers are yet properly reconciled to the acceptance of this complex, unpleasant and uncertain phenomenon, whether, in fact, it might not be better to make students disprove rather than prove Hooke's Law! It is known that work since the war has been greatly accelerated on fatigue research. It is certainly none too soon. It is, indeed, astonishing how far engineers have already dared to go in raising speeds, stresses, temperatures and pressures in face of inaccurate and incomplete knowledge of fatigue phenomena. How very much further and faster they might be able to go if uncertainties were ended and the use of high factors of safety was no longer necessary! It is fundamental knowledge that is wanted, a fundamental understanding of fatigue phenomena. Will a single session on this particular aspect, at the forthcoming symposium, we wonder, serve to advance that understanding? At least we hope that those who contribute to it will bear in mind the need to interpret their findings to engineers if their work is to bear fruit.

INTERNATIONAL INTERNAL COMBUSTION ENGINE CONGRESS

The choice of The Hague as a stage for the forthcoming International Internal Combustion Engine Congress has a certain felicity which will not be lost on those delegates who recall the contributions made to the scientific history of the seventeenth century by Christiaan Huygens, born at The Hague, on April 14, 1629. We are reminded of him, it is true, whenever we look at a pendulum clock, since it was Huygens who, during 1656–1657, applied the pendulum vibrating between cycloidal checks as a device for regulating the motion of clocks. But it is not alone for this famous *Horologium Oscillatorium* that we honour this illustrious Dutchman, since by his experiments with the gunpowder engine he became the first to introduce (about 1680) the piston and cylinder as constituent parts of a heat engine. We read, moreover, how it was on the recommendation of Huygens that Denis Papin was appointed an assistant in the laboratory of the French Academie Royale des Sciences, so that there is, in Papin's piston and steam cylinder, a reflection of the earlier collaboration with Huygens. Apart from his brilliance as a mathematician, astronomer and natural philosopher, Christiaan Huygens was a great humanist and at a time of severe international stress he remained on the most friendly terms with scientists and engineers throughout Europe. It is to be hoped that during the Congress at The Hague the international spirit so powerfully exemplified in Huygens may be influential in charging the proceedings with that friendly accord which is so effectual a stimulant of true progress.

In the case of the meeting at The Hague, thirteen nations are sending representatives and there have been submitted, for discussion, twenty-eight papers. Of these as many as fourteen relate specifically to internal combustion engines (and transmission equipment) for rail traction. Coming at a time when momentous decisions are pending as to traction equipment for British Railways, it is satisfactory to read that upwards of eighty British delegates are expected to attend the Congress. Certainly the titles of the papers convey the impression that a very wide field has been covered in so far as relates to the use of oil engines for rail traction. Included among them are communications relating to experience and developments on railways all over the world and we note that considerable attention is paid to the respective claims of two-stroke and four-stroke engines as well as of various transmission systems. The conference comes at a time when, in the United States, the number of steam locomotives in service has dropped—for the first time in over a hundred years—below the 10,000 mark. Of these, moreover, some 30 per cent were stored serviceable as on August 1, 1954, and it is stated that only one class "I" United States railroad still continues to operate its services exclusively with steam motive power while several roads have, during the past year, joined the ranks of the "100 per cent dieselized." But we do not regard as authoritative any argument for diesel-electric motive power which, based on experience in one country, is offered as definitive in respect of another country where the conditions may be profoundly different. Here in the United Kingdom a comparatively large fraction of the population is based on London and moves in and out of it at high density over a comparatively short radius. Similar conditions, scaled down, obtain in other regions where population is concentrated and the movement of traffic—as in the London area—is best accomplished by electrification. There appears to be no scope in the United Kingdom for such services as those operating between Denver and Chicago.

We live in an era of solving problems; a time when vast changes may come upon us with a rapidity the like of which we have not hitherto experienced. In such circumstances we are well advised to think hard before committing ourselves, wholesale, to any form of power or power transmission which may itself become obsolescent before there has been time to determine just what its economics really are. Recent declaration of the intentions of the British Transport Commission includes an announcement to the effect that certain plans are to be pushed forward "ruthlessly." The objection to ruthlessness in technical matters is that it may prove to be recklessness, and we have to bear in mind that profound changes may lie just below the horizon. There is an Italian proverb according to which "He who goes slowly goes wisely and he who goes wisely goes well." Having been conservative, hitherto, in the application of oil engine motive power, British Railways are likely to study carefully the various transmission systems. In the report contributed by the railroad division of the American Society of Mechanical Engineers at the annual meeting (New York), November 28–December 3, 1954, it is stated that while the use of non-electric drives in other than small power units has, during the past year, made no significant progress in the United States, "the German builders are continuing the trend—as reported last year—towards the use of hydro-mechanical and hydraulic drives in preference to the electric drive extensively employed in the United States." We must bear in mind that the United Kingdom and the United States are very different in their territories, their requirements and their resources. All these have a powerful influence on methods. It was, indeed, a noted American industrialist who remarked that "The true function of the engineer is, or should be, not only to determine how physical problems may be solved, but also how they may be solved most economically." *Omnia tempus haben* is a principle which we neglect at our peril and it must be hoped that while unflagging energy and all the wisdom which we can command is applied to the problem of rail traction, no precipitate action will be taken. It is with this in mind that we wish every success to the forthcoming Congress at The Hague, which presents an altogether exceptional opportunity for the exchange of information on some matters which, at this time, are of the highest importance and of special significance for the future of British Railways.

Short Notices

Fishing Boats of the World. Edited by Jan-Olof Traung. London: Arthur J. Heighway Publications, Ltd., 107, Fleet Street, E.C.4. Price 90s.—This book is not intended as a text book on naval architecture but, as the title suggests, deals with the design, construction, powering and equipment of all forms of fishing craft. It deals with that part of fishing-boat design which is not to be found in text books on naval architecture and is based on seventy papers presented at the F.A.O. International Fishing Boat Congress held in Paris and Miami in 1953. The discussions on the papers are also included and form a valuable supplement to the papers, which are grouped in four main sections. One group is mainly concerned with the various classes of boats engaged in a wide variety of fishing operations, while a second group deals with problems of naval architecture such as tank testing, hull forms, stability and safety at sea. Various forms of propulsion are examined in the papers in the third group, and comparisons made between two-stroke and four-stroke diesel engines of low, medium and high-speed, gas turbines and diesel-electric drive. This group also discusses problems of vibration, control systems, and various items of deck gear. The fourth set of papers is devoted to factory ships and their operation. The book, which contains over 600 illustrations, including photographs, general arrangements, line plans and detail drawings, forms a comprehensive reference work for all those concerned with the fishing industry.

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Foundation Engineering. By Rolt Hammond. London: Odhams Press, Ltd., Long Acre, W.C.2. Price 21s.

Precast Concrete. By Kurt Billig. London: Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 32s.

Magnetic Amplifiers. By H. F. Storm. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 108s.

Fluid Dynamics of Jets. By Shih-I Pai. London: Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 37s. 6d.

Electric Traction Engineering. By E. A. Binney. London: Cleaver-Hume Press, Ltd., 31, Wright's Lane, Kensington, W.8. Price 15s.

Oxford Junior Encyclopædia. Vol. VIII, Engineering. London: Oxford University Press, Amen House, Warwick Square, E.C.4. Price 30s.

Heat Conduction. By L. R. Ingersoll, O. J. Zobel and A. C. Ingersoll. London: Thames and Hudson, Ltd., 244, High Holborn, W.C.1. Price 32s. 6d.

German Industries Fair, Hanover

No. I

THE German Industries Fair, which opened on Sunday, April 24th, and closed on Tuesday, May 3rd, again combined the heavy and light industries fairs. The enlarged exhibition spaces in the halls, and in the open air, were all filled. This year there were no heavy machine tools, as they are to be shown at Hanover at the International Machine Tool Exhibition, which will take place from September 11th to the 20th this year. The opening ceremony did not take place as in former years on Sunday morning. An informal dinner was held on Saturday evening, April 23rd, to which some 500 or more exhibitors and Fair representatives, along with members of the press, were invited. The Landes Finance Minister, Alfred Kubel, welcomed those present on behalf of the Deutsche Messe und Austellungs A.G. of which he is chairman, and on behalf of the Government of Lower Saxony. The Hanover Fair, he went on to say, had grown into the largest trade fair in Europe, and he thanked all who had worked so hard to achieve this desirable end, particularly those who, in 1947, had taken the first steps. Director Dr. Carl Hundhausen of Krupps, and one of the members of the Fair Board, then spoke on the growing representation of the iron and steel industry, which this year had established itself in two new central buildings, that of the Rheinischen Stahlwerke of Essen, and the new building of Krupps of Essen. Other speakers included Dip-Ing Kurt Hertenstein, the managing director of the German Philips Company of Hamburg, who dealt with the growth of the radio and television industry, and Mr. Adalbert Grosse of Pforzheim, who spoke on the exhibits of the silver and jewellery sections. Tribute was paid to the officials and staff of the Deutschen Messe und Austellungs A.G. for their excellent efforts in preparing and carrying out the plans for the Fair. The accompanying site plan, shows clearly the general layout of the exhibition space. It will be seen that twenty-one halls were provided as well as the large Trade Fair House and the Annex. The total area of the Fair grounds excluding the parking spaces is 650,000 square metres, and the covered space in the halls totals 220,000 square metres, with 80,000 square metres of open air exhibition space. The total number of exhibitors this year was 3576 of which there were some 316 exhibitors from eighteen European countries and from overseas, an increase of more than 30 per cent compared with last year.

The Fair this year was enhanced by several fine new buildings in the sections belonging to the iron and steel industries, two of which deserve special mention.

On its 5000 square metre site at the back of Halls 1 to 4, facing the large area of open air exhibition space, the firm of Friedrich Krupp of Essen, has constructed a new circular exhibition hall which is shown in Fig. 2. The architect was Ferdinand Streb of Hamburg, and the construction was carried out by the Fried. Krupp Maschinen und Stahlbau of Rheinhausen. The hall which is shown in Fig. 2—the stem of a ship loaned by the Weser A.G. is seen in the foreground—has an area of 620 square metres and a diameter of 28m. The height at the sides is 11·5m and along the outer walls a series of reception rooms and offices has been built. They are fifteen in number and include a large conference hall. The entrance hall has an area of 60 square metres. Two sets of intersecting circular girders carry the roof. These girders are joined by riveting and are supported on a ring foundation member. The spaces are filled glazing bars of light profile and the square, rhombic and triangular spaces thus formed are filled with "Lamilux" plates. These were made by Heinrich Strunz of Rehau, Oberfranken, and consist of polyester resin strengthened with glass fibre. The plates have a strength nearly equal to steel and they let through about 85 per cent of the light. The effect within is of a warm yellow daylight.

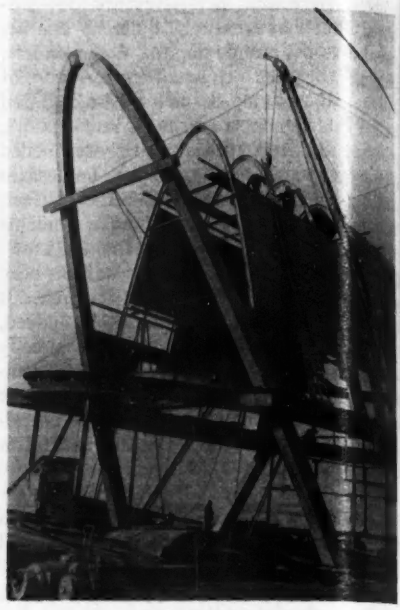
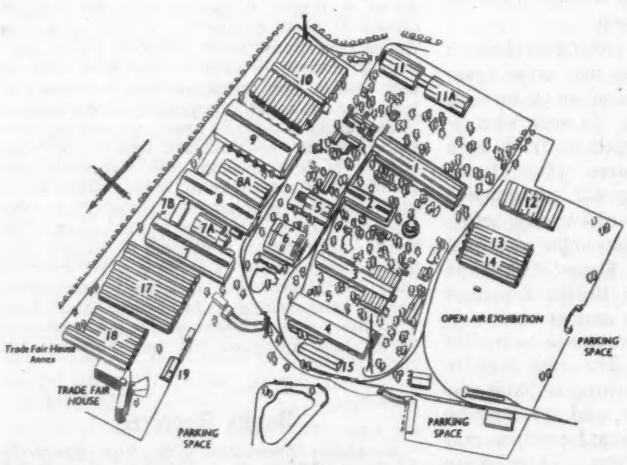


Fig. 3—The Rheinwesteisen building under construction

In this new hall Krupps and its associated companies displayed several new developments in metallurgy and machinery. Considerable interest was shown in the first examples of commercially produced titanium made in Europe. A 50 kg forging showed that the new metal makes a forging 50 per cent larger than a steel forging of equal weight. Examples of sheets, wire, strip, and screws and bolts made in titanium were shown along with specimens of the metal which had been subjected to tensile and corrosion tests. The advantages of the new metal are its low specific gravity of 4·5, combined with strength resistance to corrosion.

In the casting section examples of oil engine bed-plates and columns were shown made in high-duty grey cast iron. Of special interest was a hammer frame, weighing 5800 kg, for



1.—Compressors and pumps, valves and fittings, conveyors and hoists.
2.—Gears and drives (additional firms in Hall 7).
3.—Boilers and prime movers, furnaces and oil burners, welding appliances, and machines for the ceramic industries.
4.—Food processing machines, machines for rubber and plastics, weighing machines (additional firms in Hall 7).
5.—Precision tools and gauges (additional firms in Hall 8A).
6.—Chemistry and plastics.
7.—Air conditioning plants and dryers, workshop equipment, gears and drives (additional firms in Hall 2), cold rolled and drawn materials, laundry machines and hand knitting machines.
7A and 8.—Woodworking machines.
8A.—Precision tools and gauges (additional firms in Hall 5), abrasives and polishing materials, and machines for shaping steel.
9, 10 and 11.—Electrical machinery and equipment.
11A.—Radio and television apparatus.
12.—Iron, sheet steel and metal goods, non-ferrous metals, foundry products, building materials and motor and cycle accessories.
13.—Precision mechanical apparatus and optical appliances.
14.—Rubber and asbestos, including a special exhibit of U.S.A. rubber asbestos, and electronic apparatus.
15.—Conveyors, containers and small lifting appliances.
17.—Office and business machinery and drawing office equipment.
18.—Domestic machinery and appliances.
19.—Trade Fair House and Annex, glass, ceramics, silver wares, watches, clocks and jewellery.

Fig. 1—Site plan of Fair

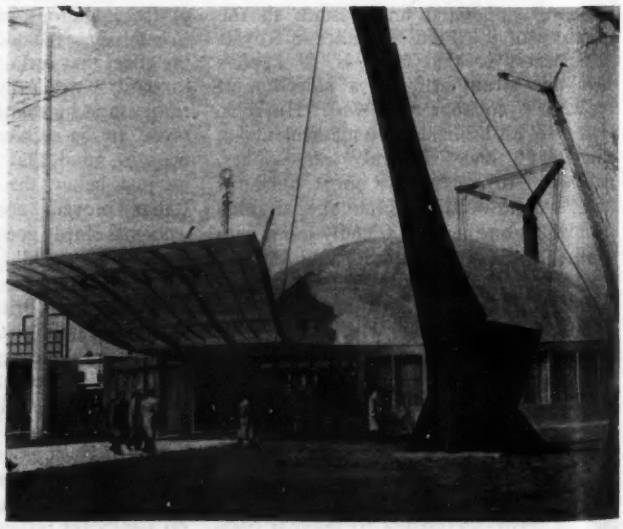


Fig. 2—The Krupp hall with ship's stem plating in foreground

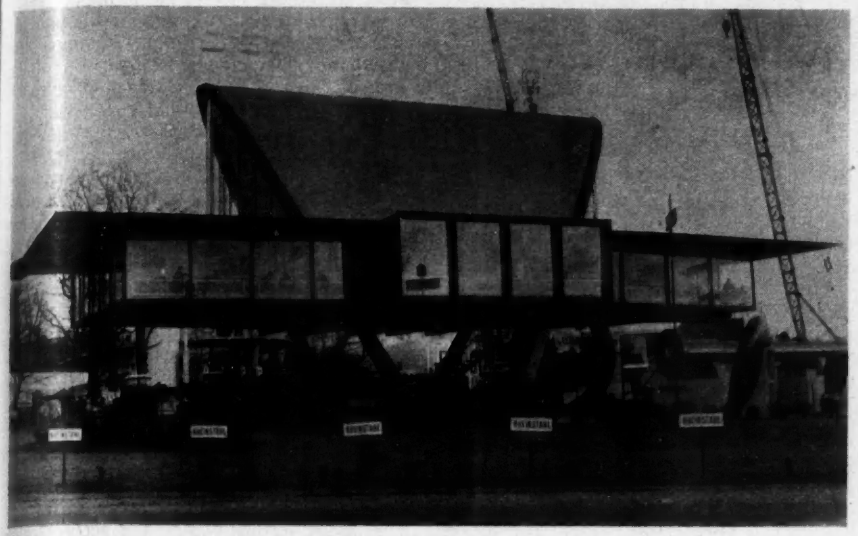


Fig. 4—The completed Rheinwestelsen building and stand

the firm of Bêché und Gross G.m.b.H., which is the largest casting yet made in this new material of ductile cast iron or "Spharoguss." The casting, which has been annealed, has a height of 2200mm and a breadth of 1780mm. The material has a tensile strength of 51 kg per square millimetre, an elastic limit of 45 kg per square millimetre, and an extension of 22·8 per cent. Among the machines we noted a new wire rope stranding machine, made by Fried. Krupp Maschinen und Stahlbau, of Rheinhausen, in which the stationary bobbins are carried within a rotating case of light construction. With this machine working speeds from 3000 r.p.m. up to 3600 r.p.m. can be used, and up to forty-eight bobbins can be accommodated in a single machine. The firm of Fried. Krupp and its associated companies is represented in the United Kingdom by J. M. J. Maus, of 35, New Broad Street, London, E.C.2.

The other building to which we would refer specially is that which was constructed for the Rheinischen Stahlwerke, of Essen, and it is shown under construction in Fig. 3 and the completed building and stand in Fig. 4. It was designed by two architects, Dip.-Ing. Geert Köster and Dip.-Ing. Dieter Stübing, with the special object of showing what could be achieved in steel construction. As will be seen from Fig. 4, the suite of offices is hung from two inclined bow girders, which have stiff steel and concrete foundations well below ground. In view of the slanting position of the two girders, all the tensional forces must be taken by the steel roof. The floor of the office building is hung from the four end girder supports by means of hangers of high-tension steel. The floor itself is supported by means of the ring girders shown, which carry radial girders to the outer edges of the floor. A cellular floor construction and a similar construction for the end walls was adopted. Access to the building is gained at the centre by means of a spiral staircase passing through an oval opening, which leads to the offices, reception rooms and a refreshment room. At one end of the building an escalator up to floor level has been provided. Some 190 tons of steel were used and the construction was carried out by Stahlbau Eggers G.m.b.H., of Hamburg. The work took about three months to complete. The group of steel firms housed in this building included the Eisenwerke Gelsenkirche A.G., Eisenwerke Mülheim Meiderich A.G., the Gussstahlwerk Gelsenkirchen, and the Rheinischen Westfälische Eisen und Stahlwerke A.G., Mülheim, Ruhr. Also the Vereinigte Economiser Werke, G.m.b.H., Hilden, and the Eisenwerke Hilden, along with the Hanomag, of Hanover; Stahlbau Eggers G.m.b.H., Hamburg, and Nordseewerke, Emden. Around the building, as our illustration shows, typical productions of these firms were arranged.

We now pass to the description of some of the exhibits of special engineering interest.

J. Pohlig A.G.

The firm of J. Pohlig, of Cologne, which has just celebrated its eightieth year since foundation, showed near to the main entrance of the Fair a typical example of its electrically operated wagon end tipper, such as those supplied to the Bundesbahn and other European railways. It is designed to deal with a standard German goods truck. It is provided with a standard loose end for tipping. The tipper—Fig. 5—is built in a foundation pit some 2·5m in depth. This accommodates at the left-hand end the double-barelled winch and driving motor, and provides room also for the articulated levers and the underbase of the tipper, which is built of steel and strengthened by side plates. Two wire ropes pass round triple pulleys —Fig. 6—at the buffer end and drive on to the articulated levers shown in the foreground of Fig. 6. The two carrying wheels engage the shaped undercarriage and perform the lifting operation up to an angle of a maximum of 60 deg. The motor unit, shown to the left of Fig. 6, operates the two buffer stops which will be seen at the foot of the wagon in Fig. 5. They are of segmental shape and engage the buffers of the wagon so that it cannot move forward while tipping. When the operation of discharging is completed the buffer stops can be completely withdrawn, so that the wagon has a free passage after the completion of discharge. The controls for the hoisting motor and the buffer stops are neatly arranged in a cabin at the side of the tipper along with a dial which records the exact angle through which the wagon has been tipped. The firm of J. Pohlig A.G. is represented in Great Britain by F. and G. (Carlswork) Products, Ltd., of 19–21, Palace Street, London, S.W.1.

Fig. 5—Electrically operated wagon tipper—J. Pohlig

Fig. 6—Tipping mechanism—J. Pohlig

(*To be continued*)

Technical Report

National Building Studies Research Paper No. 21, *Studies on Bridge-Deck Systems* 1 : *Tests on a Model Jack-Arch Slab*. H.M. Stationery Office. Price 4s.— The design of steel-concrete bridge-deck systems is at present based mainly on arbitrary assumptions and experience has shown that the reserve of strength in such structures is much greater than that calculated. In order to bring about greater understanding of the mechanics of bridge-deck systems and to find out more about their behaviour under load the Building Research Station has carried out, at the request of the Ministry of Transport, an investigation of various systems of this sort. The present publication is concerned with the behaviour of jack-arch slabs. It outlines the theory of the jack-arch and describes tests carried out on a model jack-arch slab built in accordance with the design of a full-scale bridge selected as representative of its class.

The model slab, which was supported on a span of 9ft, was subjected to three groups of tests. It was first tested at working loads, then at working loads after systematic cracking of the concrete, both with and without tie-bars. Finally, tests to failure were made, including tests on bending and punching strength. The publication describes the tests and test results in detail. From the test data it was possible to deduce the effective cross section for the slab tested and a later report will give general guidance on the design of jack-arch bridges.

Institution of Naval Architects

ANNUAL SPRING MEETING

No. VI—(*Continued from page 639, May 6th*)

AFTER completing the business of the general meeting, which was held on Wednesday morning, April 6th, with the President, Viscount Runciman, in the chair, the following paper was presented :—

LINERS OF THE PAST, PRESENT AND FUTURE ON SERVICE EAST OF SUEZ

By Sir William Currie, G.B.E.

SUMMARY

Two P. and O. liners are compared, the "Marmora," built in 1903, and the "Arcadia," completed in 1954. Particulars of the ship's hulls are given together with the main details of the machinery and of the electrical installation, while further tables show numbers of passengers and crew carried. Cargo, fuel and water capacities are compared and longitudinal sectional drawings serve to point out the difference in general layout and to illustrate trends in design. Constructional changes are discussed ; and also form coefficients and the increase in beam. The question of finance is broadly considered and average figures are quoted for passenger and freight rates, and various items of expenditure, both sets of figures being related to a ton of displacement.

DISCUSSION

Sir Charles S. Lillicrap : Sir William has commented that there has been no spectacular improvement in shipbuilding such as there has been in the realms of aircraft development, nuclear physics and electronics. The reason is not far to seek, for many years ago the sound scientific basis of our industry was settled by the researches of Froude and others ; the results of their researches were implemented, and consequently all that we can hope to do now is to reap small advantages here and there. The newer industries are still in their infancy and are bound to start off with a spectacular appeal, but their rate of progress in the future will certainly not be anything like so spectacular.

In section 9 of the paper, dealing with finance, we have some very startling figures. The earning capacity of the "Arcadia" is eight times that of "Marmora" ; that appears to be very good, until we note that the first cost of "Arcadia" is twenty-six times that of the "Marmora," and that the costs of repairs and maintenance are eighteen times as much.

The steel weight/displacement is 0·351 for the "Arcadia," whereas for the "Marmora" it is 0·396. But in Table VIII of the paper the weight of hull as compared with displacement is 0·575 in "Arcadia," as against 0·529 in "Marmora." Is this an indication of the multiplicity of fittings and equipment which go into the modern liner ? It seems to me that the naval architect has saved steel, only to have that saving swallowed up by items of equipment which would not have been carried in earlier days.

In another table the author refers to the work of Noah. The motto of the Worshipful Company of Shipwrights, of which Sir William is an eminent Prime Warden, is "Within the Ark, safe for ever." If that is a true description, the naval architect of to-day has still a long way to go. The quest for the unsinkable ship is still as unsuccessful as the quest for the Philosopher's Stone, although to-day we have approached more nearly to success.

I notice that the "Marmora" was fitted with hydraulic cranes for handling the cargo, but in the "Arcadia" the lifting appliances are derricks. Why have we gone back from cranes to derricks ?

I am delighted that Sir William takes the view that the air is never likely to be a complete substitute for the sea, and feel certain that he is right, and I agree with him entirely. I am sure that nearly all of us here will agree with him.

With regard to the last paragraph of the paper, which is in the nature of a challenge, I want to give Sir William the assurance that, whatever the future, immediate or distant, and whatever the motive power may be, whether it is nuclear power or gas turbines, naval architects and shipbuilders will be unceasing in their efforts—and that applies particularly to this Institution—to give him and his colleagues the very best vessels which science and engineering can produce.

Sir James M. McNeill : This paper is very searching in its analysis and is fair in its comparisons.

I agree that progress in shipping over the last half-century has been comparatively small in relation to that in many other industries, but in relation to the railways it has made vast strides in every one of its essentials. It must also be remembered that many of the modern inventions have been superimposed on ships' equipment as compared with fifty years ago, and also twenty-five years ago.

The author states that one reason for the "beamier" ship is the greater margin of stability now required in passenger liners. That has been an obvious requirement since the promulgation of the 1948 Safety of Life at Sea Convention. Even in the short space of time which has elapsed since 1948, the beam has increased and the naval architects must be very careful now to ensure that the beam is adequate to meet all these requirements.

There is reference to the precautions governing fire detection and extinguishing. In addition to satisfying statutory requirements we have also to provide more subdivision of accommodation, safeguard stairways, and provide additional escapes, and that inevitably means the elimination of revenue-producing space.

I am very glad to see that Sir William has a great respect for Father Noah. Speaking from memory, and taking the cubit as 18in, the dimensions of the Ark were something like 450ft by 75ft by 45ft. I will make a prediction with regard to these ratios of dimensions, that by the end of this century the maximum dimensions of ships will approach these ratios. One means of solving the shipping problem from the economic point of view must be a still further increase in beam and still further efforts to achieve the maximum revenue-earning space within the shortest possible length and the lowest possible first costs.

An important item is the distilling plant capable of supplying water both for domestic purposes and for boiler feeds. This system, in the development of which I think the P. and O. were the pioneers, is probably the largest single item and will have the most influence in the design of large passenger ships.

The costs of building ships are in large measure beyond the control of shipbuilders. For example, the author states that the first cost of the "Marmora" was £250,000 ; that figure would not cover the cost of the steel that went into the "Arcadia" before it was delivered to the builder's yard. That gives an indication of what is happening in regard to the cost of ships. Although the increase of costs of building ships over fifty years are staggering, a comparison of the costs of two fighter aircraft of practically the same dimensions shows that one constructed during the late war cost £7500, while the present-day fighter costs almost £100,000.

With regard to the future, the allowances to be made in connection with the replenishment of fleets should be based on the fact that to-day we are producing ships which bear no comparison with those we are replacing.

An important item which could be considered in connection with liner design is that of the provision of boats for all ; we ought to be content with far less boats and davits and should substitute the more modern life rafts.

Sir Colin S. Anderson : I want to take the point of view of the customer of the naval architect, and one of the things which we should try to arrive at in the design of large passenger ships is a more orderly arrangement in the vertical planning of accommodation. I feel sure that the shipowner is to blame ; he seems to demand a different kind of cabin on deck A from that on deck B, yet another type on deck C, and yet in a modern hotel each room on the first floor is similar to the same room on the eighth floor.

About the derrick versus the crane, a very simple reason for using the derrick is that it will cover a far greater area laterally, and on a large ship that is important, particularly when working over both sides simultaneously.

Another matter is the use of aluminium, and whoever can make use of it in a large liner will reap advantages. One of the difficulties in its use will be in connection with fire precautions, and it will be necessary to consider if aluminium, when coated with fire-resistant materials, will have a weight getting towards that of steel. Another problem is that as we add to the speed we find that what was a pleasant breeze has now become an intolerable hurricane, and we have to give a lot of thought to the creation of draught-free pockets of fresh air on deck.

We should apply lessons learned from aircraft engine development to our own engines. The newest aeroplane can work up to a shaft horsepower equal to that of a 30,000-ton liner within a few seconds, whereas that takes two hours in a liner.

Mr. H. A. J. Silley : Sir William's comparison of the "Marmora" of fifty years ago and the "Arcadia" of to-day shows how the modern vessel has grown not only in size, but also in complexity, and I should like to draw particular attention to how this affects the ship repairer.

Modern liners, due to their increased beam and considerably increased draught, have necessitated the provision of very much larger dry docks, and that problem is exercising the whole of our industry. To enlarge a dock which is 550ft long and of 60ft beam to 800ft long and 100ft to 110ft beam, will cost to-day more than the cost of three docks in the period from 1918 to 1939.

Sir James McNeill has referred to ships of the future moving towards the ratio of dimensions of the Ark. I hope he is right, because we have been working on that basis in designing the dimensions of our dry docks. We have to deal with the tanker, with its enormous increase of beam ; we have to consider the draught of the "Arcadia" class, and the additional beam required in dry dock when refitting, repairing and inspecting items such as stabilisers.

We have to provide services arising out of the developments of the last quarter or half-century ; employ specialists in the various trades and more expensive and

complicated machinery as compared with the days of the "Marmora."

There is an increasing demand by owners of ships for special treatment of the hulls in dry dock, and it is a matter for regret that in this country we are not able to give the service which can be obtained abroad, particularly in the United States, with sandblasting on ships' hulls. We are up against questions concerned with resistance by labour and all kinds of regulations, Home Office and Factory Act requirements.

Mr. K. C. Barnaby: It is staggering to note from the paper that, while annual earnings have gone up only about 2·4 times per ton, first cost has gone up eleven times. If our lifestream is not to become too attenuated, the builder must make every effort to combat these spiralling costs. It is true that most of them are quite outside his control, and equally true that building costs could be reduced by increased productivity. This does not need longer hours or harder work, but it does involve greater readiness to adopt new methods and to abandon restrictive practices and the eternal internecine warfare between different trade unions.

It is claimed by union officials that the admittedly high standard of craftsmanship of the British worker is largely due to the specialisation involved by so many unions. It is difficult to concede any truth in this when two unions each claim that their men alone are qualified to undertake some new but perhaps quite trivial job.

Mr. L. Lenaghan: The change during the past fifty years which has impressed me is the great increase in electrical power on board ship, and there is evidence to-day in passenger liners that the electrical load will continue to increase. On the engineering side there has been far more progress than on the side of naval architecture. I find that the machinery horsepower per ton weight in the "Marmora" is 5·1 and in the "Arcadia" it is 11·75, which suggests that the modern ship produces more than 2·3 times the power per ton of machinery. Machinery changes are a sign of progress; nevertheless, they present many problems. In two exactly similar ships built for different owners, the horsepower being the same in both cases the difference in machinery weight was roughly 800 tons; with such a difference in machinery weight there are many problems, particularly of stability.

Stabilisers are essential as we know them to-day to offset discomfort to passengers resulting from higher G.M. But the stabiliser is very much in its infancy, and I do not foresee the present type of stabiliser having a long life. I feel that as an alternative we may have to consider certain changes in form, and if we are going towards larger beam the question of stabilising will become of great importance, and I wonder if there is something in the jet principle that could be introduced to offset rolling.

One extraordinary comparison is the difference in the consumption of fresh water on the two ships; the "Arcadia" uses almost ten times as much as the "Marmora" used—on the basis of the numbers of crew and passengers. Whether the fresh water is provided by evaporators or is taken on board at various ports, it is certainly a very expensive item.

Mr. E. L. Champness: In regard to cost, one would hope that references to that matter might be accompanied by a table showing the changes in the value of the £ over the years, because then shipowners would find that they are really getting a lot more than appears from the figures of first cost in the analysis.

(To be continued)

Electrical Research Association's Annual Report

THE thirty-fourth annual report of the British Electrical and Allied Industries Research Association reviews the activities of the Association during the year ended December 31, 1954. Reference is made to progress on the new E.R.A. buildings at Leatherhead,* which are stated to be fairly well advanced, to the extent that the expected date of occupation, in the spring of next year, allows a small margin on the contract time.

Some aspects of E.R.A. research programmes are summarised in the following abstracts from the report.

During the year Professor Newitt published details of the primary pressure standard for his steam research plant to provide data up to 1500 deg. Fah. and 6000 lb per square inch. Data on long-term creep of austenitic, molybdenum-vanadium, chromium and molybdenum steels up to 1065 deg. Fah. are in course of publication and results are available for 30,000 hours' testing from which behaviour for 100,000 hours can be forecast; such work is supported by the British Iron and Steel Research Association. With special assistance from the B.E.A. and manufacturers a test rig has been planned at a power station for tests on welded pipes under accelerated service conditions. The British Non-Ferrous Metals Research Association continues its work on the corrosion of condenser tubes.

The surge injector unit for low voltage argonarc welding has been used by a member in welding aluminium cable sheaths and another member is in course of producing units under E.R.A. British and foreign patents to meet requests from various countries. The British Welding Research Association co-operates in arc welding researches.

The variation of breakdown voltage with thickness and time in insulation tests has so far remained an unsolved problem. This year Mr. J. H. Mason's work on the effect of discharges on dielectrics has yielded a quantitative explanation over a wide range. Further progress has been made with the new dry oxide dielectric film and on the use of hydrogen-acceptors in impregnated capacitors. The Ministry of Supply supports this work. The long-term programme at the N.P.L. on the electrical properties of newer dielectrics now extends in frequency up to 24,000 Mc/s and in temperature to the higher limits now possible. In parallel a large programme on industrial testing has been pursued, including glass, sleevings, cotton covered wires, terylene, cellulose compounds and insulating oils: temperature classification and tracking have received attention.

Fundamental work on dielectrics has included the influence of strong electronic interaction in solids, plasma oscillations in solids and the theoretical effect of dipoles on dielectric breakdown to explain the E.R.A.'s previous experimental discoveries.

Mr. King and Dr. Bruce have propounded a purely thermal theory of the concentration of arc-like discharges—a general problem so far unsolved, with a particular application to switchgear. The theory of the split cathode discharge has been published and so has the theory of the anomalous rotation of cathode spots. Work on cathode mechanisms continues at Oxford University, on spark formation at Liverpool University and at Durham University on microwave breakdown in gases, which is often the limitation to the transmissible microwave power. The new 3MV surge generator at the N.P.L. has made possible the study of flashover on insulator strings of 20 units, in addition to the work on impulse corona and the breakdown of composite dielectrics.

All Area Boards now supply data for the statistical study of lightning faults and reports cover 1951 and 1952: in 1953–54, 7000 reports were received. A report on lightning activity from thunder-storm observations covers 1953. Continuous surge recording and observation of surge filters has continued. Agreement between theory and experiment has been reached on aspects of surge voltage distribution in transformers and a scale model of a very large transformer is now available. By the time this report is published a current transformer will have been demonstrated for measurement and protection at very high voltages, in which the conventional magnetic coupling is replaced by a beam of light, which greatly simplifies insulation.

Members of the Association have successfully applied at higher powers the E.R.A. formula for pressures in explosion pots in oil circuit-breakers. Work on air-blast circuit-breakers includes the aerodynamics of the flow through nozzles and the detailed study of electrical characteristics round current zeros. The survey of the restriking voltage characteristics of the British 132kV and 275kV networks has been published and the collection of data for the 33kV network continues. Work on fuses has included the heating of fuse terminals, multi-way fuse boards and enclosed fuses. Long period tests on contactors have continued.

Work on insulated cables has mainly related to economical use. The study of ducted cables, cyclic loadings, and thermal properties of the soil have the object of heavier loadings and the new standard ratings will usually be higher than those of F/T128, which they will replace. The revision of short-circuit ratings is similarly advanced. There is also economy in using 400 c/s for some equipment and corresponding current ratings will soon be issued. Research on overhead lines bears mainly on the vibration of conductors, effect of polluted atmospheres and efficiency of arcing devices (Queen Mary College).

The work by B.I.S.R.A. on electrical sheet steel, supported by the E.R.A., has so far concentrated on the effect of small impurities both with reference to hot and cold rolled silicon iron. At University College, London, measurement of losses extends now to flux densities of 24,000 gauss at 50 c/s. At Perivale the E.R.A. is developing a test of the insulation of laminations. Some unexpected low temperature effects on Alcomax have been found by the Permanent Magnet Association. Professor Sucksmith has continued work on high field properties of dilute anisotropic ferromagnetic alloys. Professor Bates, using the Bitter figure technique, has demonstrated the principles of domain growth and its influence on magnetic properties. At Cambridge new methods of structure analysis have been worked out. The N.P.L. is obtaining results on the long-term stability of permanent magnets.

The E.R.A. network analyser was inaugurated in April, 1954, with full measuring and control equipment and part of the full quota of network elements. It has successfully met the needs of a variety of problems posed by members covering regulation, surge protection, self-excitation and a search for sources of overvoltage in a large supply network.

Work on rural electrification continues with the support of the Ministry of Agriculture and Fisheries and in co-operation with Reading University. The versatile dryer operated successfully in 1954 on a farm: with a heater loading of 16kW an annual output of 30 tons of dried herbage and 80 tons of grain is possible. Basic laboratory work on drying covers as wide as possible a range of seeds and products. Other studies concern the electric tractor, electric drives for machinery, weed killing and soil sterilisation. The heat pump for milk cooling and water heating has undergone tests at the National Institute for Research in Dairying and will now go to a farm. Poultry researches are still directed to the increase of egg production by light flashes and environmental control.

A second paper on the effect of current and inductance on the fine transfer in low-voltage contacts has been published, and the work has extended during the year to palladium, silver, gold and tungsten, and to higher voltages with improvements in oscillographic technique. Erosion of ceramics in the surface spark ignition plug has received fundamental study since it limits the useful life of this device.

Hydrogen-oxygen fuel cells have run for hundreds of hours in the laboratory and series and parallel operation has been demonstrated. For the first time, therefore, a high output, high efficiency fuel cell with a commercial life has been achieved. The next stage is that of directed development research, which interested members are considering. A small panel is examining some suggestions for conventional accumulators.

* THE ENGINEER, October 22, 1954, page 563

Bar Heat-Treatment Plant

A FURTHER stage in a programme of plant modernisation and extension being carried out in the tool steels and engineers' tools works of Arthur Balfour and Co., Ltd., Sheffield, was recently completed with the inauguration of a line of three new gas-fired bar annealing and heat-treatment furnaces. The new line of furnaces, shown in the accompanying illustrations, had been laid down partly in a shop which was previously equipped with pulverised coal-fired furnaces for the same work, and partly in an adjoining new bay. The new bay houses the furnaces and the old bay houses a charging machine served by an overhead travelling crane.

The three batch furnaces supplied by Gibbons Brothers, Ltd., of Dudley, each have a heating chamber 5ft wide, 2ft high and 16ft long. They are served by a Gibbons-Van Marle electric charging machine and batches of material for heat-treatment are prepared and cooled on two loading tables adjoining each furnace.

The furnaces are fired by town's gas on the "Gibbons-Webb Roof" combustion system augmented by special long-flame burners firing into transverse slots below the hearth level. This dual firing arrangement ensures uniform temperature distribution for all kinds and dispositions of load, and also enables varied rates of heating and low-temperature treatment to be carried out satisfactorily. The roof combustion system embodies an arch perforated with regularly spaced holes of uniform size through which preheated combustion air flows in the form of small jets into the fuel gas below.

Gas is introduced through ports spaced along each side of the furnace and situated immediately below the springing line of the roof arch. The resultant combustion produces a uniform blanket of flame across the width and along the length of the furnace chamber. Combustion gases after enveloping and heating the load are evacuated through controllable ports in the furnace hearth into two recuperator chambers immediately below and after passing over recuperator tubes they finally flow into the chimney.

Each burner section of a furnace has its own metallic recuperator in the form of aluminised hair-pin-shaped tubes for preheating the combustion air. Each tube is fitted with a control valve on the cold air inlet side, and air is supplied under pressure from an electrically driven fan. After passing through the recuperator tubes the air flows through insulated pipes contained in the double-channel furnace buckstays and then enters a hot air reservoir built in brickwork above the perforated roof from which it descends through jets into the heating chamber.

Each furnace is divided into two temperature-control zones for the roof combustion system and each zone is governed by a "Kent" variable-speed floating and proportional controller which operates automatic combined air/gas valves. This equipment gives close automatic temperature control over the wide range of fuel supply associated with long heat-treatment cycles where the load is raised to the temperature required and is then held at that temperature or allowed to cool slowly over a period of several hours.

The automatic air/gas control valves are designed to give a constant air-to-fuel ratio over the whole range of valve opening and it is, of course, possible to vary this air/fuel ratio to give oxidising or reducing conditions in the furnace atmosphere. The chimney damper is automatically controlled by an "Electroflo" regulator which varies the damper opening to suit the fuel input, thus maintaining a constant positive pressure in the furnace chamber.

In the hearth there are three longitudinal slots. The centre slot is used as a collecting duct for the hot gases prior to their leaving the chamber. The two outer slots, which are fitted with flat heat-resisting steel rails, receive the arms of the charging machine.

Charging machine with loading arms partly extended into furnace. The charge loading tables can be seen on the right of the furnace

The charging machine has two parallel runways which register in front of the outer pair of slots in the furnace hearth. Two sets of arms, arranged one above the other, are traversed along the runways by a roller chain-operated head. The lower set of arms runs on cast iron rollers through which the load is supported on the machine and the furnace floor. The upper arms, which carry the material to be heat-treated on cross bearers, are fitted with rollers at intervals and slide longitudinally on the lower arms. When these upper arms are moved in respect to the lower arms their rollers ride up inclined blocks fitted in the lower arms and they are raised clear of the lower arms to elevate the load a few inches above the normal hearth level.

For the charging operation the upper arms with the load are raised and advanced into the furnace supported on the lower arms. At the limit of extension into the furnace the upper arms are lowered to deposit their load, together with the cross bearers, on the hearth, and the two sets of arms are then retracted back on to the charging machine runways. This procedure is reversed when unloading the furnace.

The machine is capable of carrying a maximum load of 10 tons and has a travelling speed along the shop rails of about 100ft per minute. It is fitted with three motors, one for the arm lifting movement, one for traversing the arms into and out of the furnace, and the third for travelling along the shop floor. Electrical interlocks are provided so that it is impossible for the machine to travel in either direction unless the arms are fully withdrawn from the furnace slots.

Annealing charges are worked out on the isothermal characteristics of the individual steels, the heating cycles being designed to give the optimum annealed structure for ease of machining, maximum hardenability and freedom from decarburised surface.

New line of three bar-annealing and heat-treatment furnaces and charging machine bay

Civil Engineering Research and Development Centre

ON April 27, 1955, we attended the official opening by the Minister of Works, the Rt. Hon. Nigel Birch, of the research and development centre of John Laing and Son, Ltd. The decision to erect the new centre at Manor Way, Boreham Wood, Herts, dates back to 1953, when the company's various plant and process research sections were first formed into a single department. These sections had themselves come into being in the years after the war as a result of the increasing stress laid in civil engineering on novel methods and materials, especially on more and better mechanisation. In addition to sections dealing with plant development and with mechanical and electrical engineering, there is a section concerned with research and experiment, and an architectural and structural engineering development section, as well as a concrete laboratory, a soil mechanics laboratory and a technical library.

After the opening ceremony, visitors were shown over the premises and by inspecting the many examples of work being carried out were enabled to form an impression of the very varied activities of the department. Of the laboratories, those devoted to chemistry and physics are equipped for the routine testing of building materials and also for special investigations, such as high temperature performance.

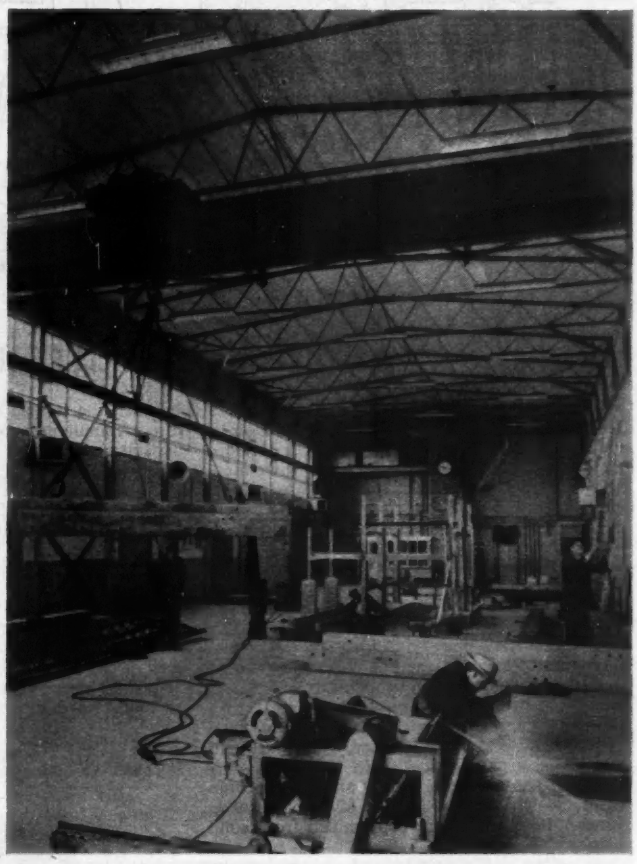
A paint and bitumen laboratory carries out chemical and physical standard testing on these materials. Bore samples from site areas are investigated in the soils laboratory, which also possesses mobile equipment for obtaining samples and for testing proposed foundations in the field. The concrete laboratory is equipped with testing machines and has been provided with a thermostatically controlled mist-spray curing room for the preparation of concrete test blocks under controlled conditions. Attached to it is an aggregate "museum" containing a continually expanding collection of samples from all over the country.

In the structures laboratory are carried out full-scale load and deflection tests of building components, such as a section of a precast concrete induced draught cooling tower, and a lightweight floor beam made from prestressed concrete "pencil" beams and sintered, powdered fuel-ash aggregate. In addition there was given a demonstration of precasting the sections of a building by the vacuum method, the building itself being shown in process of assembly in the open area outside the laboratory.

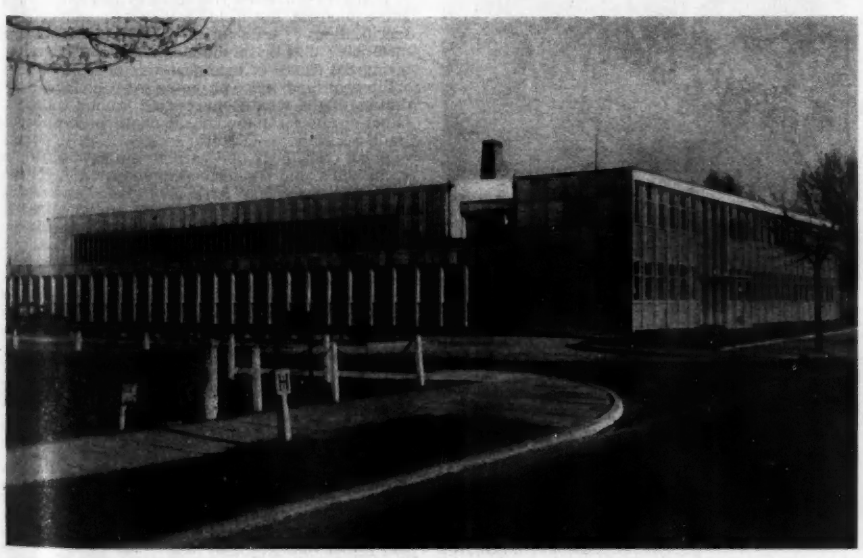
Of particular importance to the company's operations is the work of the plant development section, which constantly reviews the very large field of contractors' plant and makes recommendations for development and improvement of individual items of machinery. In given cases, new machines are developed in co-operation with the mechanical and electrical engineers' section and the plant department. The work of these sections was illustrated by such items as a power barrow with forward or lateral controlled discharge, a motor-driven float for laying concrete floors, a small tamper for granular filling material, and a range of small tools. Among the outdoor exhibits were shown a continuous automatic concrete batching and mixing plant which the company had imported from abroad for experimental purposes; a hand-operated drag scraper; a scale model spreader; a crane for use on small buildings, and other items, such as a pilot plant for sintered pulverised fuel ash.

The building, which is shown in our first illustration, provides a total floor space of approximately 18,000 square feet. Our second illustration shows the layout of the structures laboratory. Besides the building there is an area of some 12,000 square feet available for the performance of outdoor tests. The "L"-shaped section of laboratories and offices is assembled from precast concrete frames designed to a module of 4ft 7in. This provides uninterrupted window walls and at the same time allows freedom in the placing of partitions. Each frame has a deep groove in the jamb on either side, which, together with a similar groove in the abutting frame, forms a permanent shutter for columns cast *in situ*. Metal windows are fitted to the upper part of the frames and precast, aggregate-faced panels to the lower.

These slabs are backed by a "Thermalite" inner wall, with a cavity between. A service duct situated immediately below the sill houses the electrical and telephone wiring. The first floor and roof are constructed from flat slabs cast *in situ*, and the end walls have precast concrete panels outside and wood wool slabs on the inside, the intermediate space forming a permanent shutter for a concrete core. Metal reflectors on the columns near the service duct provide indirect lighting and the acoustic ceiling is fitted with low temperature heating panels.



Interior of structures laboratory, which is of conventional steel-framed design clad with asbestos sheeting and lined with fibreboard

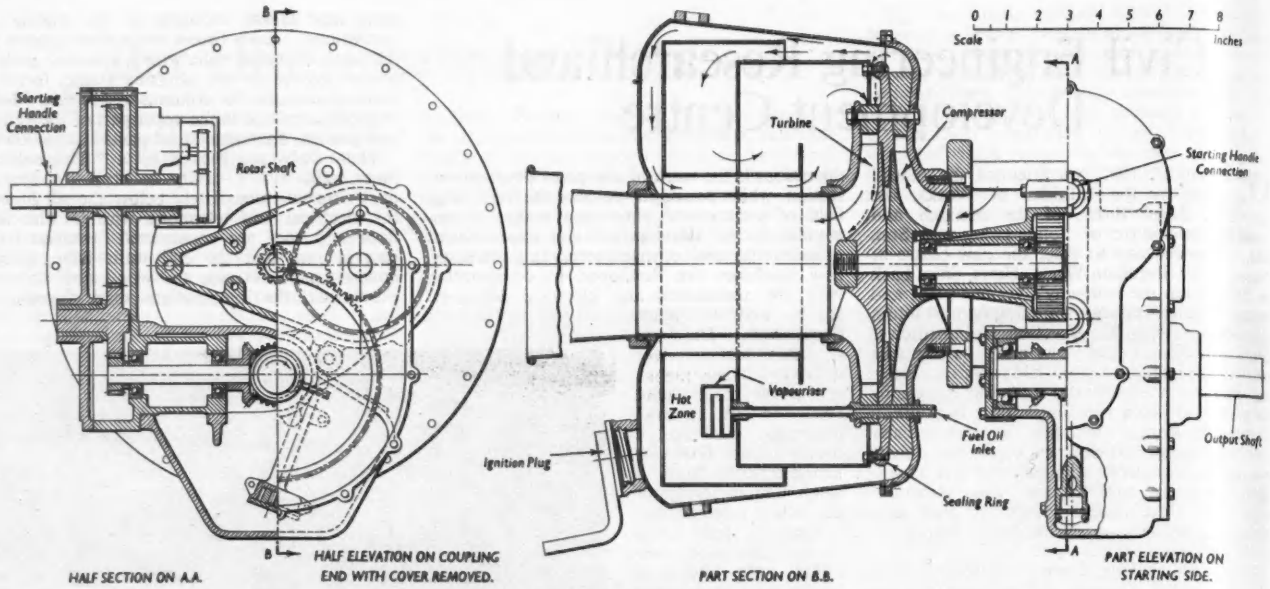


Laboratories and office block, constructed from precast panels with steel-framed laboratories and workshop behind

The structures laboratory, concrete laboratory and workshop block are of steel, clad with asbestos sheeting and lined with fibreboard. In order to enable the temperature in the concrete laboratory to be controlled, this part of the building has "Thermalite"-lined cavity walls and double-glazed windows.

Architects were S. Greenwood, A.R.I.B.A., and H. N. Michell, A.R.I.B.A., with J. Przeslak as assistant architect.

DRY DOCK AT KARACHI.—The port of Karachi is to have a new dry dock, to complement the smaller naval dock recently completed, so that it will no longer be necessary for ships to go to Malta and Singapore for repair. This dock, which will take vessels up to about 12,000 tons, has been commissioned by the Pakistan Industrial Development Corporation. It represents an important advance in the economic progress of the country, we are informed, as Pakistan will now be able to expand its merchant fleet. The German firm of Stulken Sohn have been appointed to act as consultants, and the contract for the dock was secured by the British firm of Gammon (Pakistan), Ltd. The dock will measure 632ft long, 90ft wide and 38ft deep, and with ancillary pump houses and storage rooms is expected to take two and a half years to complete. The design incorporates anchorage cables, to resist hydrostatic uplift under the floor of the dock.



General arrangement of 60 h.p. gas turbine

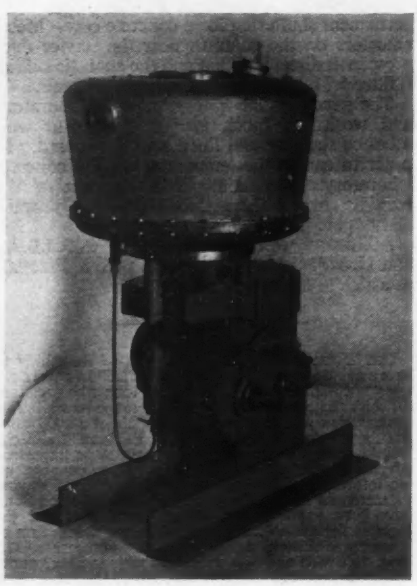
Small Gas Turbine

A GAS turbine notable for its overall simplicity and compactness, particularly in relation to its fuel and control system, is that under development by David Budworth, Ltd., shipbuilders and engineers, at Harwich. It develops 60 h.p. at a shaft speed of 45,000 r.p.m. and weighs only 60 lb. It could be contained in a package 16in by 16in by 16in when coupled to a 15 : 1 reduction gear as shown in the drawing. It has been primarily designed for auxiliary and portable power requirements and at the moment two of these installations are undergoing acceptance trials for the Admiralty.

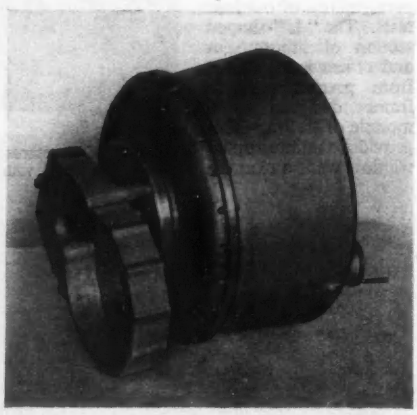
The unit has a designed compression ratio of 2·8 : 1 and the maximum temperature of 850 deg. Cent. An overhung rotor assembly consists of a centrifugal impeller and a radial-flow turbine clamped back to back between a shoulder and nut on an austenitic steel shaft. The light alloy impeller has fourteen vanes and the turbine rotor, which is of Nimonic 80A, has twelve vanes. Both rotors are copy milled from solid blanks.

A sealing ring penetrates radially the jointing faces of the two discs, providing a small clearance between the tongue of the sealing ring and the disc. A small pressure differential across the discs assists a small flow of cooling air around the clearance space.

After compression air passes between twenty-eight lozenge-shaped diffuser pieces bolted between a cast aluminium front housing and the sealing ring, which is of cast iron. The flow divides into three principal streams ; the primary air takes the central course to the hot zones in the region of the three vaporisers ; the secondary air stream flows around the outer combustion case and assists the cooling of this member as well as the exhaust cone and turbine nozzle ring. It will be noted that the third stream is turned through 180 deg. and passes around the bulb flange of the sealing ring and down to the nozzle ring, where it has been established from the nature of the carbon deposits that this relatively cool stream effectively scrubs both the ring and the face of the rotor before finally losing its identity in the main flow.



Gas turbine arranged with rotor assembly vertical



Gas turbine without reduction gearing

The internal can of the combustion chamber is fabricated from Nimonic sheet and is located from the sealing ring. The outer chamber is supported entirely from the body flange and is thus free to expand symmetrically in all directions.

Vaporisation takes place in three vaporising containers placed in the hot zone and the temperature of these can be adjusted by varying the proportion of primary/secondary air. All fuel passages in the hot part of the turbine are of large diameter and cannot become choked. The fuel pressure is only a few pounds per square inch higher than that of the combustion chamber and the variation of this pressure difference with speed provides a simple method of governing, the fuel pressure being kept constant by a relief valve.

The unit is started by a starting handle by step-up gearing, the self-sustaining speed being about 5000 r.p.m. The engine is normally supplied without any electrical equipment, the fuel being lit with a match before winding up commences. Electric starting can, however, be fitted, if required.

One of the illustrations shows an alternative bevel reduction gear, which may be preferred for some purposes, and the other shows the basic turbine unit.

Book of Reference

Ship and Boat Builder Annual Review, 1955. London : John Trundell (Publishers), Ltd., Temple Chambers, Temple Avenue, E.C.4. Price 30s.—As in previous editions, this year's *Ship and Boat Builder Annual Review* contains a number of directories of value to those concerned with small craft. British builders and repair yards are listed in both alphabetical and geographical order and overseas boat builders are grouped alphabetically in order of countries. Particulars of main and auxiliary engines are given in tabular form and associated with the names of individual manufacturers and data concerning outboard motors is presented in a similar manner. A section of the review is devoted to materials, fittings and equipment and includes : paint manufacturers' specifications ; directories of marine fittings and materials ; data on shipbuilding timbers ; a directory giving the names of manufacturers of items of yard equipment, and followed by an index giving the addresses of the manufacturers and leading suppliers. Other directories in the volume relate to consultants, trade associations, technical societies, British owners of small craft, dock and harbour authorities, British yacht clubs, and commercial diplomatic officers and trade commissioners. Articles of interest and related to various aspects of the industry are contained in the volume, and some of the subjects discussed are trends in tug propulsion, small craft of the N.A.T.O. navies, trends in the pleasure craft market, new marine equipment and British small craft. Some remarks are given about the National Boat Show and Mr. J. D. Calder has contributed an article entitled " Outlook for the Industry." Other subjects discussed concern the growth and current advantages of diesel propulsion, the place of the small steam engine, radio-navigational equipment in small craft, deck machinery for small craft and a description of the methods of building small craft in plastics.

MOBILE RADAR UNIT.—Decca Radar, Ltd., has recently built a mobile radar unit which consists of a specially constructed caravan which has ample space to accommodate up to ten people. The caravan is hauled by a Land Rover which is fitted with a 5kW generator, belt driven from the main engine and which provides the power to drive the radar alternator and other electrical services. The new Decca 212 radar set is installed in the unit and will be demonstrated at all the ports of the United Kingdom during the next few months.

Gasworks Extensions at Stoke-on-Trent

Extensions which have been completed at the Etruria gasworks at Stoke-on-Trent include ninety-six continuous vertical retorts with a nominal daily capacity of 8,000,000 cubic feet of gas. The installation is complete with a new coal and coke-handling plant

A NEW installation with a nominal daily capacity of 8,000,000 cubic feet of gas recently inaugurated at the Etruria gasworks, Stoke-on-Trent, forms a completely self-contained extension adjoining the main works. The site acquired for the new installation was restricted and the adoption of the tower design purifier allowed the plant to be arranged across the site in four parallel lines at right angles to the adjoining main railway lines. These plant lines contain respectively the retort house and coke screening plant, shown in one of the illustrations on this page; the detarrers, condensers, exhausters, reciprocating gas compressors, generator and switchgear house and ammonia washers; the oxide store shed and tower purifier installation; and the building for the station meters and calorimeter room, benzole washers, tar and liquor wells, benzole recovery plant, water circulating pump house, rail weighbridge house, water cooling tower.

The main contractor for the new plant was the West's Gas Improvement Company, Ltd., and the carbonisation plant consists of ninety-six Glover-West 50in continuous vertical retorts grouped in four separate benches, each of three settings, each setting containing eight retorts in heating units of four and designed for balanced heating. Fuel gas is supplied to each setting by a pressurised integral step-grate producer. These producers are coupled together by common external producer gas flues, one to each bench, with branches to the individual settings and the necessary control dampers. Primary air is supplied to each bench from a motor-driven fan by way of a common duct with branches to each grate; steam is injected into each branch.

Following the work of the British Refractories Association on the behaviour of refractories at Etruria, advantage has been taken in this installation to compare under identical conditions some of the standard materials now available. Retorts and combustion chambers in each of the four benches have therefore been built in a different refractory material, and it is proposed to keep them under observation and to report to the industry in due course.

Waste heat from the retort settings is recovered in three Spencer-Bonecourt boilers. Each boiler is capable of dealing with the gases from two of the four benches, but can work efficiently on reduced loading when all three boilers are in operation. The boilers are designed to raise steam at a pressure of 180 lb per square inch, superheated to 150 deg. Fah. above saturation temperature, at the rate of 4 lb of steam per pound of coke consumed in the producers. The induced draught unit of each boiler consists of a "Sirocco" fan with 20 per cent volumetric overload capacity driven by a Greenwood and Batley geared-back-pressure, steam turbine exhausting at 30 lb per square inch. This exhaust steam can be used either for steam supply to the retorts or for feed water heating purposes.

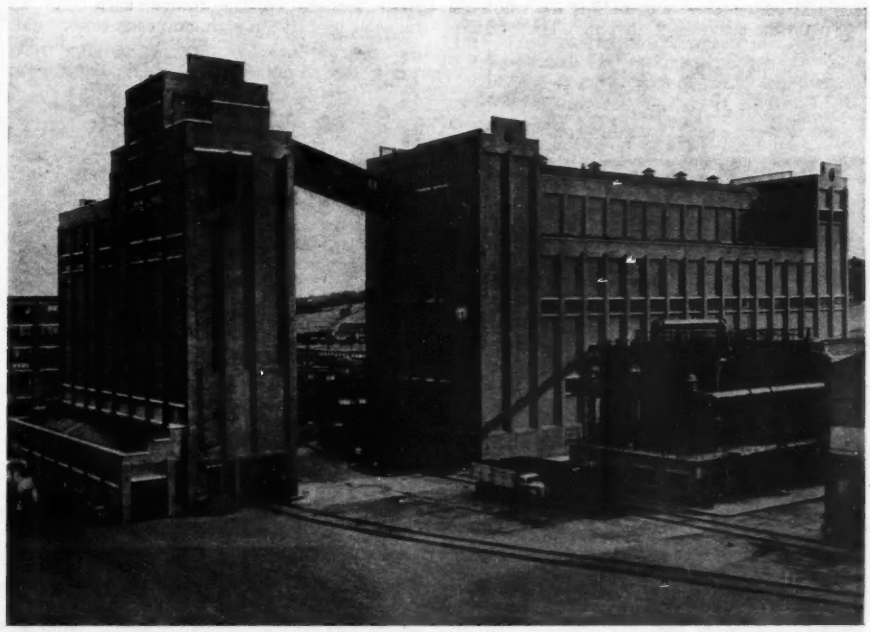
Coal Supply

Coal is received from rail or road at both ends of the retort house, and in each position hydraulic ram wagon tippers are installed. The coal is discharged into a 25-ton receiving hopper extended on the outer side to receive coal from road vehicles. Below each receiving hopper is a mechanically operated and adjustable reciprocating feeder, delivering coal to a single-roll coal breaker capable of reducing 80 tons of coal per hour to sizes not exceeding 2in cube. The coal passes to an inclined steel tray conveyor delivering to bucket conveyors arranged across the end bays of the retort house. Conveyors deliver coal to either of two 42in band conveyors arranged over the coal bunkers above the retort benches. These conveyors, used for distributing coal to the bunkers, are reversible, so that they can receive coal from the conveyors at either end of the house. Each band is equipped with four travelling ploughs (two facing each direction of travel), which can be lowered or raised as required.

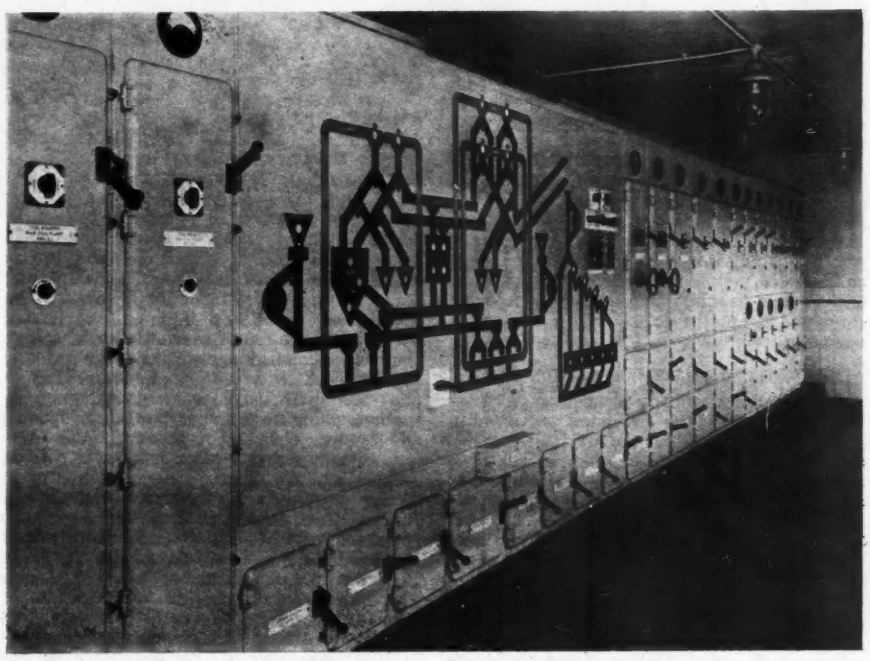
Coke Handling

Coke is discharged from the retorts by vertical helical extractors driven by reciprocating bars actuated from the end by an electric motor, a vertical steam engine being installed as standby. Independent sets of extractor driving gear provided at both ends of the house are so arranged that either can be used to drive the whole plant, or, alternatively, each can drive half of the equipment.

From the extractors coke passes by way of a travelling chute to one of two 36in wide belt conveyors in a longitudinal trough below the retort house floor. The conveyors are reversible so that coke can be conveyed to either end of the retort house. At the coke plant end the coke is elevated and delivered to either of two 30in. troughed belt conveyors which cross the yard and deliver to the grading plant above the coke storage bunkers or it may be delivered to the producer and retort-feed hoppers at that end of the house. At the railway end of the plant coke is elevated and delivered by a bucket conveyor into either a 175-ton storage hopper, a producer feed hopper, or a retort feed hopper. The coke can be discharged from the 175-ton hopper into road vehicles or it can be reclaimed



Retort house and coke grading plant of Etruria gasworks extensions

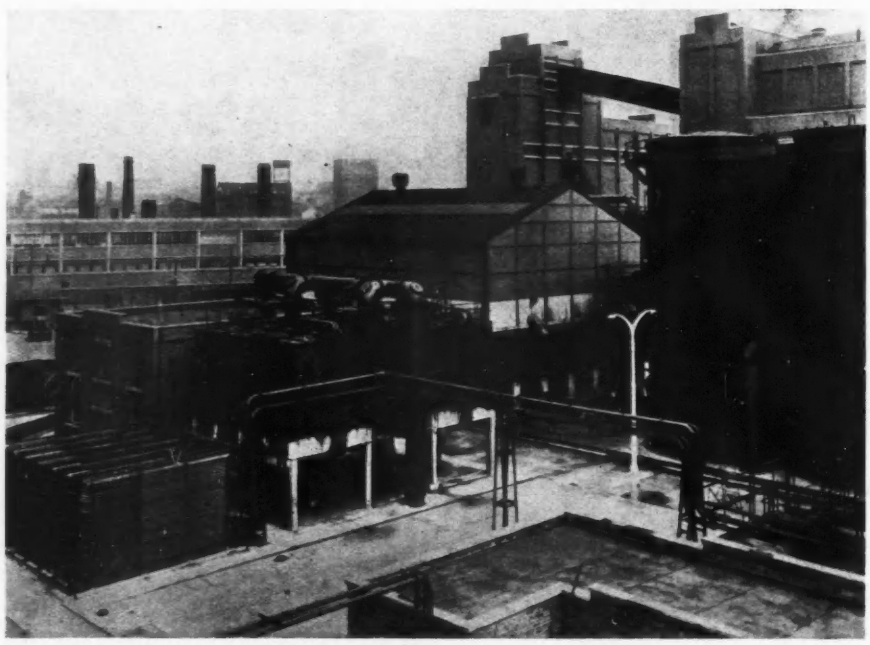


Illuminated control panel in starter house

by chute to either of the band conveyors below the retort benches and thence to the grading plant.

The coke storage bunkers with the grading plant above and the loading platform below are built as a tall structure encased in brickwork similar in architectural appearance to the retort house building. The total storage capacity of 700 tons is divided into five compartments for different coke sizes. Coke for producer feed and that required for filling the retorts after scurfing is stored at both ends of the retort house. At each end debreezing screens are fitted to the outlets for producer coke and the whole section is enclosed to prevent the egress of dust. A producer feed runway for coke extends the full length of the house with two electrically propelled skips passing over an Avery automatic weigher and totaliser in which all fuel consumption in the retort benches is weighed and recorded. A retort feed runway extending the full length of the house has two skips for charging the retorts with coke after scurfing.

With the exception of the waste-heat boiler fans and boiler feed water pumps the whole of the plant is electrically driven. The starters for the motors of the coal and coke handling system are mounted on a composite control panel housed in an annexe to the retort house. This control panel is complete with all necessary interlocking contacts and switches to ensure the correct sequence starting and stopping of the several motors. A master panel which can be seen in one of the photographs we reproduce is placed centrally in the control panel and on it are mounted the selector switches and a "visual flow" mimic diagram which indicates by coloured strips and lamps the actual units which are in operation.



Counter-current benzole washers and rack coolers, tower purifiers and oxide store shed

Wet and Dry Purification

Three Holmes primary condensers of conventional vertical tube design on an overhead reinforced concrete structure work in parallel, and each has a normal capacity of 5,000,000 cubic feet per day. Each of three Holmes-Elex electrical detarrers on the same overhead structure is capable of handling 5,000,000 cubic feet of gas per day in the hot saturated condition. The condenser and detarrer equipment is arranged to allow great variation in working conditions during condensation to assist in maintaining control on the composition of the final works effluent.

Two high-speed Holmes-Connersville exhausters directly coupled to 110 h.p. vertical steam engines are each rated at 12·9 million cubic feet of gas per day. Each exhauster is capable of working against an outlet pressure of 48in w.g. while maintaining a vacuum of 6in w.g.

The main storage well is divided into four compartments for works liquor for disposal, liquor from retort house circulation and hot gas detarrers, tar from retort house and detarrers, and light creosote oil separated from the gas following the hot gas detarrers. The essential feature of the system is the separation of condensates into two aqueous and two hydrocarbon fractions with minimum loss of time. The polyhydric phenols which cause trouble during the bacterial oxidation of liquor effluents are segregated to a considerable extent from the normal works liquor for disposal. Two static "Multifilm" washers, connected in parallel, are provided to remove ammonia, and each washer is in the form of two six-bay units arranged in series.

The dry purification plant consists of a set of tower purifiers installed by W. C. Holmes and Co., Ltd., and having a working capacity in one stream of 10,000,000 cubic feet per day. There are six working towers, each 22ft 3in diameter by 52ft 9in high, and each tower holds twelve double-layer containers of octagonal form provided with timber grids.

The towers have a bottom gas chamber into which the gas enters and flows up the continuous individual gasways in each container. Gas connections are provided for reverse rotation working of the towers. A stocking tower and stocking frame of similar dimensions to a working tower are installed, together with a spare set of containers which are kept filled with fresh oxide for speedy changing of a tower. The purifier set is served by a 60-ton Goliath crane of 64ft span by the use of which any tower can be completely emptied and refilled in a working day. Revivification air can be introduced to any tower by Connersville blowers and a purging machine allows routine purging before opening any tower for changing purposes.

A benzole recovery plant supplied by W. C. Holmes and Co., Ltd., is designed to extract 85 per cent of the available benzole from the gas. In this plant, illustrated herewith, two static countercurrent "Multifilm" washers are provided for washing the gas from the new retort house. Benzolised oil from these washers, and also from washers extracting benzole from other parts of the works, is stripped by the vacuum distillation process. The washers have a capacity of 10,000,000 cubic feet per day, while the oil-stripping section, having an hourly oil circulation design rate of 8500 gallons per hour, is planned to handle oil from washers having a total capacity of 20,000,000 cubic feet of gas per day.

The steam-raising plant consists of three Spencer-Bonecourt multi-tubular, waste-heat boilers situated in the retort house. The steam, which is generated at 180 lb per square inch and 150 deg. Fah. superheat, is fed into a high-pressure steam system from which supplies are taken for process requirements in the retort house (steaming of retorts and producers), driving the waste-heat boiler induced draught fans and feed pumps, the steam engines of the exhausters, and the turbine-driven pumps of the crude benzole plant. The surplus steam is used in turbo-alternators to generate electricity or is passed into the existing works steam system.

Except for the alternator turbines, all this steam plant is designed to work against a back pressure and discharge into a low-pressure steam system designed for a normal working pressure of up to 30 lb per square inch. For normal working, the aim is to balance the amount of steam discharged into the low-pressure system with that required for process work at the benzole plant and for steaming retorts. This is made possible by having duplicate sets of motor-driven pumps at the benzole plant and selective control of the steam and the motor-driven pumps ensures economic flexibility of the low-pressure steam system.

The volume of gas produced in the plant is measured by two Holmes-Connersville positive displacement meters, each with a normal rated capacity of 450,000 cubic feet of gas per hour at up to 48in water gauge.

In the same house as the exhausters are two variable-speed, motor-driven gas compressors, each having a capacity of 400,000 cubic feet of gas per hour at a maximum pressure of 15 lb per square inch. These compressors are used for pumping gas from the 5,000,000 cubic feet capacity waterless gasholder of the plant by way of a 20in diameter high-pressure steel main into the low-pressure distribution system.

High-Frequency Germanium Point-Contact Transistor

A NEW high-frequency germanium point-contact transistor (designated "EWSI") has been developed by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. Its main use is in pulse circuits (such as circuits for amplifying, forming and shaping of pulses), and it is therefore likely to be of considerable importance as a component in digital computers.

Used as a pulse amplifier its speed of response is such that, if the rise time of the input waveform is 0·05 microsecond, the rise time of the output waveform is less than 0·15 microsecond (usually less than 0·10 microsecond). If the input waveform does not cause the transistor to "bottom" (a condition of high collector current, low collector voltage, in which further increase in the amplitude of the input signal does not increase that of the output) the fall time of the output waveform will be approximately equal to the rise time. If bottoming occurs the fall time will be increased because of the "hole storage" effect; the actual increase will depend on the degree of bottoming and the duration of the pulse. In a typical case the current gain factor (α) falls to 0·7 of its low-frequency value at a frequency of 4 Mc/s. This means that it can be used in high-frequency amplifier circuits when a low noise factor is not the main requirement (a typical noise factor value, measured at a frequency of 1 Mc/s, is 20 db). The low value of the interelectrode capacitances (1 to 2 pF) is also important.

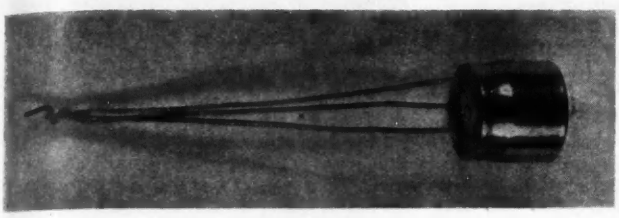
Some details of the characteristics and performance, as stated by the manufacturer, are given herewith.

To obtain this performance the spacing between the metal whiskers at their points of contact on the germanium surface is made very small (approximately 0·001in). The assembly, illustrated here, is designed to withstand mechanical shock and vibration and can be stored at temperatures of up to 70 deg. Cent. without change in characteristics. The transistor is hermetically sealed in a metal container, measur-

ing ¼in in diameter and ¼in in length. It has successfully withstood a test in which it was cycled daily for eighty-four days to an elevated temperature in a very humid atmosphere.

Characteristics and Performance

The transistor "bottoms" at a collector voltage of the order of 1V; this is advantageous in circuits operated from a low d.c. supply voltage. The "off" collector current (i.e. the current that flows at a given collector voltage when the emitter current is zero), although slightly higher than in some types of point contact transistors, is almost independent of temperature over the allowed range of operating ambient temperature. Increasing the ambient temperature from 20 deg. Cent. to 50 deg. Cent. causes the "off" collector current to increase by only about 10 per cent.



High-frequency point-contact transistor

The maximum allowable values of collector voltage, collector current and collector dissipation are −20V, −15mA and 100mW respectively. Typical values of "off" collector current, I_{co} (with emitter current zero) are −1·5mA and −2·2mA at collector voltages of −10V and −20V respectively. At −10V the transistor is specified to have a value of I_{co} less than −2·5mA.

When the emitter and collector currents are 3mA and −5·5mA respectively, the collector voltage is less than −1·3V; in a typical case the value of this collector "knee" voltage is 0·8V.

At a collector voltage of −5V when the emitter current is changed from 0 to +1mA the change in collector current corresponds to an average value of current gain, α, of 3 in a typical case. The transistor is specified to have a value of α, measured in this way, of not less than 2. When the emitter current is changed from +1mA to +2mA a typical transistor shows a value of $\alpha = 2$.

The maximum storage temperature is stated to be 70 deg. Cent. and the maximum operating ambient temperature 50 deg. Cent. The collector dissipation must not exceed 30mW.

When a pulse, having an amplitude of 3mA, a duration of 0·5 microsecond and rise and fall times of 0·05 microsecond, is applied to the emitter of a transistor, with a collector load resistance of 75 ohms and a collector supply voltage of −15V, the rise and fall times of the observed collector current pulse are less than 0·15 microsecond. (This test is normally done with a small amount of positive static emitter current (+0·3mA) so that the input resistance of the transistor is not excessively high at the start of the pulse.) Thus the transistor is suitable for amplifying pulses of even as short as 0·5 microsecond duration.

If the collector load is increased, in the above test, to a value of 1500 ohms and the amplitude of the input pulse to +10mA the rise and fall times of the collector current pulse are less than 0·15 microsecond and 1·5 microsecond respectively. Under this test condition the transistor is "bottomed" with both emitter and collector currents approximately +10mA and −10mA respectively.

Crawler Tractor for Earthmoving Operations

A DIESEL crawler tractor for operating heavy earth-moving equipment is a recent product of the Caterpillar Tractor Company. Its distribution in this country is being handled by the Fred Myers Tractor Company, 4, Tilney Street, London, W.1. The tractor, which is illustrated herewith, has been designated the "D9"; its length is 17ft 10¾in, width 9ft 11¼in., and height 8ft. 9in., and its drawbar horsepower is put at 230. The power is provided by a four-stroke, overhead valve, six-cylinder diesel engine, 6¼in bore and 8in stroke, which has a governed speed of 1200 r.p.m. Alternative drives are available, either by an oil plate clutch with six-speed (forward and reverse) transmission, or a three-stage torque converter with 5 : 1 ratio. The transmission used with the torque converter provides for three forward and two reverse speeds. With the direct drive the forward speeds vary between 1·6 and 6·8 m.p.h., and with the torque converter the forward speeds are 0 to 4·1 m.p.h., 0 to 5·7 m.p.h. and 0 to 7·8 m.p.h. For starting up there is an independent two-cylinder petrol engine, with a 6V electric starter. Pressure lubrication and full-flow filtration are provided in the main engine, transmission, steering clutch, and each final drive. All the accessories are driven from a gear behind the crankshaft, and the arrangement is such that there is constant power drive for rear-mounted equipment. The track equipment comprises a seven-roller frame. There are forty-three shoes to each track, the standard shoe width being 24in. The length of the tracks on the ground is 129¾in, the area of the ground contact, with the standard shoes, being 6228 square inches. The complete tractor is strongly built and the controls are readily accessible from the driver's seat. The oil clutch, steering clutches and brakes are power assisted and throughout the design care has been taken to give as great a degree of safety in operation as possible.

Crawler tractor shown operating a heavy scraper. The tractor is driven by a six-cylinder diesel engine rated to give 230 drawbar horsepower at 1200 r.p.m.

Beyer-Garratt Locomotives for East Africa

DELIVERY has now started from the works of Beyer Peacock and Co., Ltd., of thirty-four "59" class Beyer-Garratt locomotives which are stated to be the most powerful metre gauge locomotives in the world. These locomotives were designed to the requirements of the East African Railways, which has 3100 route miles of metre gauge track, the two main routes being the Mombasa-Nairobi-Kampala line and the Dar-es-Salaam-Tabora-Kigoma line.

The leading particulars of the locomotives are as follows:—

Cylinders (4), diameter and stroke	20½in × 28in
Coupled wheel, diameter	4ft 6in
Bogie wheel, diameter	2ft 9in
Truck wheel, diameter	2ft 9in
Wheel base, each unit	30ft 10½in
Wheel base, rigid	15ft
Wheel base, total	92ft 6½in
Length over buffers	104ft 2in
Height (rail to top of chimney)	13ft 5½in
Width over cab	10ft
Axle load	21 tons
Adhesive weight	159·5 tons
Fuel capacity	2,700 gallons
Water capacity	8,600 gallons
Total weight (in working order)	252 tons
Tractive effort at 85 per cent B.P.	83,350 lb
Tractive effort at 75 per cent B.P.	73,540 lb
Boiler pressure	225 lb per square inch
Boiler barrel, diameter	7ft 6in
Length between tube plates	15ft
Heating surface:	
Tubes	3,313 square feet
Firebox	248 square feet
Total evaporative surface	3,561 square feet
Superheater	747 square feet
Total surface	4,308 square feet
Grate area	72 square feet

The locomotives are fitted for oil burning but the design is such that if required they can be converted to coal burning with a mechanical stoker. Provision is also made for their conversion to 3ft 6in gauge if necessary at some later date.

The maker recently invited a number of guests to the Gorton works to see one of the completed locomotives and inspect others in course of construction. In welcoming the guests on behalf of the company, Mr. Wilmot spoke of the difficulties which had been experienced by the East African Railways. He pointed out that despite the troubles, however, new records were being set in the amount of traffic handled. The order for the "59" class engines had been placed without any prototype being called for and showed the confidence of the railway, which had 149 Beyer-Garratt locomotives in service, handling some 60 per cent of all traffic on the lines.

Replying to the toast, Mr. A. F. Kirby, the general manager of East African Railways, spoke of the good work which had been done by Beyer-Garratt engines. But, he said, this may be the last order to be placed for steam locomotives, as in the future diesel locomotives were likely to be considered. For this reason the railway was looking towards the United Kingdom to study the new techniques and supply what was wanted. He considered that although British industry had been too complacent and too slow in adopting new ideas, once convinced, it was capable of producing the best equipment. If Britain wished to keep Commonwealth custom it would have to undertake development work on new techniques to meet future requirements.

NICKEL ALLOYS IN ELECTRONIC VALVES.—Some of the uses of wrought nickel and nickel alloys in electronic valves are described and illustrated in a new publication issued by Henry Wiggin and Co., Ltd., Thames House, Millbank, London, S.W.1. Tabular data on physical and electrical properties are given to indicate the suitability of various grades of wrought nickel for specific requirements in individual components.

Standardisation of Radioactive Materials at the N.B.S.

BY OUR AMERICAN EDITOR

The National Bureau of Standards, Washington, D.C., has been the official custodian of the American standard of radioactivity since 1926, when the U.S. Government received its first calibrated radium sample. The recent advances in nuclear physics and the widespread use of radioactive isotopes in science and industry has led to an extensive programme of research and development at the Bureau aimed at producing various standards of radioactivity. As a result, the N.B.S. now maintains and distributes fifty-five samples of radioactive isotopes and more than 700 other standards for use in all fields of engineering and the physical sciences.

TO meet the growing requirements of industry and of research workers in the fields of physics, chemistry, biology and medicine, the National Bureau of Standards is currently engaged in an extensive programme of research and development aimed at producing standards of the radioactive isotopes. In addition to radium calibration, the Bureau also measures, in terms of the primary radium standard, the radon content in samples of air from rooms in which radium is processed and in the breath of the personnel handling the material. Furthermore, the availability and comparative inexpensiveness of radioactive cobalt-60 has caused such an increase in the number of requests for cobalt standardisation that the Bureau recently constructed a special laboratory to perform this service.

With respect to the availability of artificially produced radioactive standards the N.B.S. now carries out routine distributions of phosphorus-32 and iodine-131 standards every six months. It also supplies standards of carbon-14, sodium-22, cobalt-60, strontium-90/yttrium-90, thallium-204 and gold-198. Furthermore, the Bureau makes available Ra D+E beta standards, Ra D+E+F (polonium-210), U_3O_8 alpha standards, and solutions of varying strength of radium gamma-ray and radon standards. Besides thus meeting the domestic requirements of the United States, the National Bureau of Standards is also engaged in a co-operative programme with the National Physical Laboratory, the Canadian National Research Council, and Atomic Energy of Canada, Ltd. The chief aim of this programme is to compare radioactive standards with a view to creating and improving international standards of radium and artificially produced radioactive isotopes. Plans have been made to facilitate international comparisons on the following isotopes :—carbon-14, sodium-24, phosphorus-32, cobalt-60, bromine-82, strontium-90, yttrium-90, iodine-131, gold-198 and thallium-204.

The present radioactivity facilities at the Bureau are divided into six laboratories. The Gamma-Ray Laboratory is responsible for maintaining the National Primary Radium Standards and for comparing with these standards radium sources submitted to the Bureau for certification. The amount of radon present in breath and air samples is compared with the National Radium Standards by the Radon Testing Laboratory. The chief responsibility of the Alpha-Ray Measurements Laboratory is the calibration of alpha-ray sources for use in military and civil defence radiation monitoring equipment. One of the major services of the Radioisotope Standardisation Laboratory is the regular distribution of phosphorus-32 and iodine-131 standards. However, of equal value is the preparation of Ra D+E standards for use as reference sources and the standardisation of other radioactive isotopes. The Nuclear Spectroscopy Laboratory is primarily concerned with the investigation of the disintegration schemes of the artificially prepared radioactive isotopes. The preparation and maintenance of hydrogen-3 and carbon-14 standards are the responsibility of the Radio-Chemistry Laboratory.

Gamma-Ray Laboratory

The National Bureau of Standards has been the established central organisation for the calibration and certification of radioactive preparations for almost thirty years. All sales of radium in America are based on weight of radium ; the determination of the milligramme content is ultimately based upon the U.S. primary radium standard. Comparison measurements between the sample and calibrated secondary standards are made with equipment consisting of a gold-leaf electroscope which is surrounded by ½cm of aluminium and 1cm of lead, respectively. Fig. 1 shows the apparatus used for these measurements, with the electroscope being situated at the far end of the long box. The operator times the motion of the gold leaf as its shadow moves across a ground glass screen which he observes. Over the years, many modifications have been made in the manner in which radium is handled, and proven systems of radiation protection for personnel have been incorporated. In the near future the present calibration system will be supplemented with an automatic recording null-method electrometer. The electrometer itself will be calibrated in terms of the original equipment, but will permit a much more rapid handling of the radium samples.

In the last few years, cobalt-60 has been increasingly used for radiographic, therapeutic and instrument calibration purposes. According to the records of the Bureau, requests for radium calibration reached a peak in 1944, at which time about 75,000 milli-curies were measured. From that time the requests have diminished, but in 1950 the quantity of cobalt-60 measured suddenly climbed to about 50,000 milli-curies yearly. To-day, the requests for the calibration of radioactive cobalt are well in excess of 1000 curies a year. The new Gamma-Ray Laboratory at the N.B.S. was built to accommodate this growing demand for cobalt calibration. It is now possible to measure sources with strengths up to 50 curies and to calibrate instruments with reference to sources of strength equal to 200 curies. The new facilities consist of a single building in which the air is constrained to flow continuously from the area housing low-activity material to the high-activity section. Thus, in the event that radium sources received in the unpacking room should leak, the danger of contaminating any other part of the building is reduced to a minimum. All construction of the building is in accordance with prescribed codes and designs governing the protection of personnel from radiation hazards.

During the past thirteen years, the National Bureau of Standards has maintained storage and distribution facilities, as well as a programme of recheck measurements of radium preparations for the National Cancer Institute. By order of this Institute, radium preparations are taken from storage and sent to various Government hospitals on loan. This and similarly regular needs for calibration of radioactive materials has fostered a programme in the Gamma-Ray Laboratory leading to the development of new techniques for the measurement of radium and cobalt. Ra D+E and strontium-90/yttrium-90 beta-ray ophthalmic applicators are now being more widely employed by the American medical profession. The U.S. Atomic Energy Commission requires that these beta-ray applicators which are supplied by the Commission be calibrated before use and specifically names the National Bureau of Standards as the agency for these calibrations.

Radon Testing Laboratory

Radon testing was inaugurated by the National Bureau of Standards in 1941, when the U.S. Navy Bureau of Medicine and Surgery requested the N.B.S. to establish a programme designed to prevent injury or death to personnel working with radium. With the use of complex electronic equipment and ionisation chambers that are continuously monitored in terms of the U.S. Primary Radium Standard, the Radon Testing Laboratory has developed methods for measuring to a high degree of precision radon of very low concentration. As a result of the co-operative efforts of the Bureau and the officials and hygienists responsible for the protection of the workers from unsealed radium, deaths and injury from radium poisoning are now considerably fewer in number.

The system for the periodic sampling of breath and workroom air starts with 2-litre "Pyrex" flasks being evacuated, packed in foam rubber in an aluminium container and shipped to uranium mines and radium installations through-

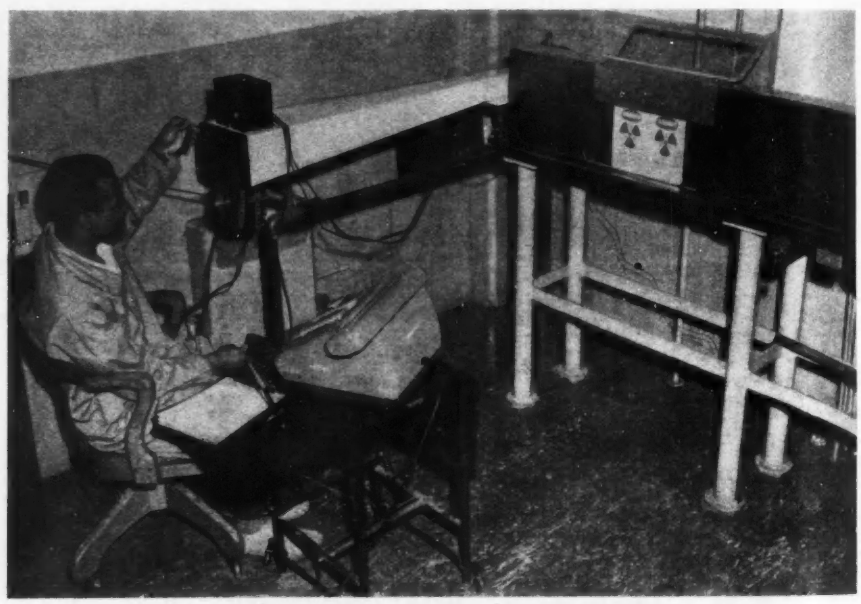


Fig. 1—Gold-leaf electroscope apparatus for the measurement of the radioactivity of radium sources

Fig. 2—Transfer of radioactive air or breath samples to an alpha-ray ionisation chamber after passage through a purification system

out the United States. A sample of the worker's breath which is to be analysed is obtained by the worker's inflating a balloon provided with the "Pyrex" flask. The balloon is then connected to the flask and the stopcock opened, allowing the breath sample to enter the flask. In the Radon Laboratory the samples are transferred to evacuated alpha-ray ionisation chambers through a purification system, as shown in Fig. 2, and analysed for their radon content. Facilities are available at the Laboratory for the simultaneous measurement of twenty-four samples. The results provide a measure of the amount of radium ingested by the workers or the degree of radium contamination of the working areas. The Radon Testing Laboratory has now expanded its programme to include the assay by the radon method of ores and sludges submitted by the U.S. Atomic Energy Commission. The laboratory also provides standard samples of radioactive ores and rocks, the radium content of which has been determined by radon analysis. Furthermore, the laboratory prepares thorium and uranium ore samples and distributes standard solutions of radium.

Standardisation of Radioactive Nuclides

Under the direct control of the U.S. Atomic Energy Commission, the production of radioactive nuclides at the N.B.S. now has reached the stage where more than 100 different nuclides are available. Approximately 80 per cent of the total volume supplied by the A.E.C. are solutions of radioactive iodine-131 and radioactive phosphorus-32. These solutions are used principally for diagnosis and therapy in brain surgery, leukemia, hyperthyroid and cancer. In order that dosage of patients shall be uniform and so that research results may be duplicated at other laboratories, the National Bureau of Standards maintains a regular distribution schedule for both nuclides. The standards are distributed in ampoules containing about 3 millilitres of solution certified as to disintegrations per second per millilitre with a stated accuracy of ±3 per cent.

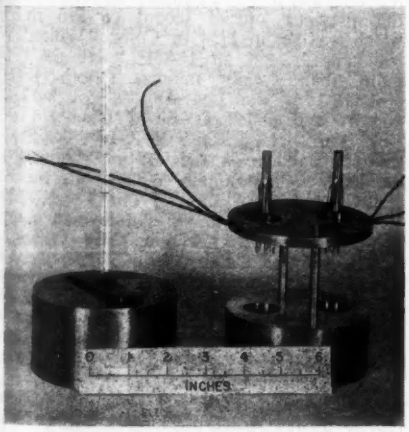


Fig. 3—Radiation balance for the comparison of primary radium standards

The standardisation of radioactive nuclides, especially those of short life, is complicated because of several factors. In the first place, because the half-life of iodine-131 is eight days and that of phosphorus-32 is fourteen days, their activity decays in a relatively short time and they become too weak for most normal uses. Therefore, it is necessary to calibrate monitoring equipment in terms of one of these two radioactive nuclide standards and a longer-lived reference source, such as Ra D+E, immediately upon its receipt. All calibrations thereafter are effectively in terms of this standard ratio. Another factor is that the calibration method used by laboratories and hospitals outside of the National Bureau of Standards must be one that can be set up and operated in a routine manner with a minimum of trained personnel and complex electronic equipment. The method which is considered to be most amenable to routine standardisation of radioactive nuclides employs either a Geiger counter or an electroscope. Sources of the same nuclide are compared directly under identical geometric conditions. However, to be a valid calibration, one of the sources must possess a known disintegration rate. For the standardisation of iodine-131 and phosphorus-32, one method that has been developed utilises Ra D+E as the comparison source. Since the activity of Ra D+E is governed by a twenty-two-year decay period and its beta-ray energy falls between those of iodine-131 and phosphorus-32, the secondary standardisation of these nuclides can be accomplished by methods already familiar in the field of natural radioactivity. Although Ra D+E has some disadvantages, its use has helped many organisations to set up equipment and to train personnel to obtain reproducible results in their calibrations.

In order to measure the disintegration rate of a quantity of a radioactive nuclide, such as iodine-131 or phosphorus-32, an effect is measured which is equal to the rate of emission by the source of radioactive particles. Because these particles are emitted in all directions, the source is placed within a gas-filled sphere; this detector is said to have 4π geometry. As the particles are emitted, the ionisation they produce is detected as pulses of current and serves as a measure of the activity. In actual practice, an almost invisible source is mounted on a thin plastic or conducting foil. Particles emitted in any direction are detected. Absorption by the source itself and by the foil mounting can be determined experimentally. The exact number of particles emitted by the source, as indicated by the ionisation pulses, is the disintegration rate of the source and from this the activity per millilitre of solution can be determined. The Radioisotope Standardisation Laboratory has also set up equipment for the primary standardisation of radioactive nuclides by beta-gamma and gamma-gamma coincidence counting techniques and by 4π scintillation counting methods. Having carried out the primary standardisation, it is necessary, in the case of short-lived nuclide, to preserve the result obtained. This is achieved, in the case of beta emitters, by a so-called 2π beta ionisation chamber and, in the case of gamma emitters, by an almost 4π gamma ionisation chamber.

Nuclear Spectroscopy Laboratory

The disintegration schemes of artificially prepared radioactive nuclides which have been determined by the Nuclear Spectroscopy Laboratory at the Bureau provide information on the properties of the nuclear energy states of the nuclide studied, and part of the data is employed in the preparation of the N.B.S. radioactive standards. In the course of its investigations, the Beta-Ray Spectrometry Laboratory has studied the decay schemes of silver-105, silver-106 cadmium-115, molybdenum-91, palladium-111, indium-117, barium-133 and antimony-120.

The facilities of the laboratory include means for the precise counting of both beta-gamma and gamma-gamma coincidences. Coincidence circuitry has been developed in which the resolving time can be accurately controlled and varied in known steps. This, together with fast linear amplification and pulse-height discrimination of the pulses from scintillation crystal detectors, enables the separation of true from random and spurious coincidences. Thus, it is possible to standardise large cobalt-60 sources to an accuracy of closer than 1 per cent. Recently, the Nuclear Spectroscopy Laboratory participated in a comparison with the United Kingdom and Canada of cobalt-60 and gold-198. The results obtained by the N.B.S. method of beta-gamma and gamma-gamma coincidences for cobalt-60 agreed to within 1 per cent with those obtained by the other laboratories. Illustrated in Fig. 3 is a radiation balance which is being used by the National Bureau of Standards to compare the activities of the British and United States primary radium standards and the Canadian National Radium Standard. A thermocouple arrangement in the balance detects the amount of heating caused by radioactive samples placed in the gold cups on top of the unit at the right. The unit is then balanced by radioactive or Peltier cooling. Here, the current required to achieve the balance is converted into microwatts, and becomes a measure of the comparative radioactivity of the samples.

Fig. 4—2π geometry proportional flow counter with hemispherical measuring chamber

Alpha-Ray Measurements Laboratory

The alpha-ray measurements programme was instituted at the National Bureau of Standards for the purpose of dealing with the various

problems associated with the standardisation, calibration and analysis of sources of alpha radiation. The programme further includes the development of techniques for the efficient detection and monitoring of these radiations. Of immediate practical application is the provision of calibrated alpha sources of a special type for portable monitoring and survey equipment used by the armed services in the field.

Alpha-ray standards of uranium oxide (U_3O_8), which emit beta radiation as well as alpha particles, are supplied by the Bureau in the form of thin electro-deposited sources on a metal backing. The alpha disintegration rate is measured in a 2π geometry proportional flow counter and means are provided to distinguish between the alpha particles which are counted and the undesirable beta particles that are discriminated against. This 2π geometry proportional flow counter is illustrated in Fig. 4. The sample to be measured is placed in the hemispherical chamber before the instrument. The Bureau's certification then gives the total counting rate of alpha particles emitted into a 2π solid angle in the forward direction. This rate is very nearly, but not quite, equal to one-half the absolute alpha disintegration rate of the sample. Consideration is also given to the back-scattering effects, which are, fortunately, offset by the small amount of self-absorption in the source. That number of alpha particles emitted per second is specified by the National Bureau of Standards to an accuracy of ± 2 per cent. The so-called 4π counter is used at the N.B.S. to measure the disintegration rates of radioactive materials emitting alpha and beta particles. Fig. 5 shows the sphere which is used to determine

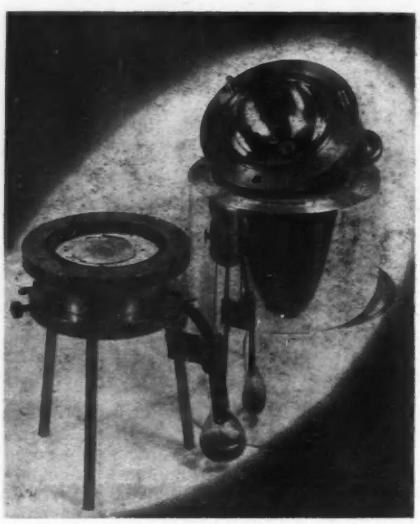


Fig. 5—Spherical measuring chamber used in 4π geometry determinations of alpha and beta particle disintegrations

these rates by 4π geometry counting methods. The radioactive sample is placed in the sphere in a methane atmosphere. The emitted electrons, beta rays or positrons ionise the methane and an amplification or avalanche results. A potential difference of 3000V exists at the collecting electrodes with respect to the sphere, and particle production is measured as voltage pulses at the output of the collectors.

Another activity of the Alpha-Ray Measurements Laboratory is the calibration of Ra D+E+F for use as alpha standards. This kind of source, if properly prepared, is a very desirable standard for several reasons. It is possible to compare the alpha activity of Ra F (polonium-210) with the beta activity of Ra E. Furthermore, the alpha radiation from Ra F consists of a single line in contrast with the double line from uranium oxide. The ratio reaches a constant value for about two and a half years. The proper preparation of the Ra D+E+F standard involves the chemical separation of the plating solution so as to have pure Ra D. It has been found that Ra F present in ordinary stock solution comes out of solution to an unknown extent and hence vitiates the temporal predictions of alpha activity (the latter component decays with a 138-day half-life). Therefore, to obtain accurate alpha standards measurements must be made in the 2π geometry.

Radio-Chemistry Laboratory

In the preparation of tritium (hydrogen-3) and carbon-14 standards, the Radio-Chemistry Laboratory employs the method of compensated gas counting. This technique uses, in the case of carbon-14, a carbon dioxide/carbon disulphide counting gas mixture in a pair of length-compensated Geiger-Müller counters. By using paired counters, end effects are eliminated and the counting rate is effectively that obtained from a perfect cylinder of gas of length equal to the difference in length between the two counters. Standards of carbon-14 are distributed in ampoules containing 25·0 millilitres of sodium carbonate solution and have a certified value of 1280 disintegrations per second per millilitre. At the present time, work is starting on the preparation of the tritium standards. When carbon-14 standards were initially prepared, a comparison was carried out between the National Research Council of Canada, the Massachusetts Institute of Technology, and the National Bureau of Standards. The results obtained were, respectively: 1330, 1410 and 1280 disintegrations per second per millilitre. Pending a further check the calibration value has been arbitrarily defined as the latter value and the standards are distributed as a basis of comparison only between the various research laboratories.

The Radio-Chemistry Laboratory has also developed a technique of 2π formamide counting as a means of secondary standardisation. The detecting instrument is a water-cooled 2π counter of the usual hemispherical form. The electronic amplifier is modified to count the total activity arising from thin layers of formamide solution. The output is fed directly into a commercial scaler. Formamide, an organic solvent of extremely low vapour pressure, is used as the vehicle in which solutions containing the radioactive nuclides are dissolved. These solutions include: sodium carbonate (C^{14}), sodium phosphate (P^{32}), cobalt sulphate (Co^{60}), strontium nitrate (Sr^{90}/Y^{90}), potassium iodide (I^{131}), potassium auricyanide (Au^{198}), and thallous nitrate (Tl^{204}). The dissolved solutions are placed in a shallow vessel, which is then inserted into a 2π proportional counter. The thickness of the solvent is adjusted for beta-ray emitting isotopes so as to obtain slightly more than a saturation layer of activity. Any thickness greater than the saturation layer will, for beta emitters, not increase the counting rate determined by the 2π counter. A fixed thickness and, therefore, volume is used for nuclides emitting both gamma radiation and beta-rays. N.B.S. standard solutions of any one of the nuclides concerned are used to calibrate the equipment. The detecting instrument need be calibrated by only one standard radioactive nuclide because the efficiencies for the other nuclides using the same cell dimensions are always a constant ratio. This technique now appears extremely useful for routine measurements and much more desirable than the defined-geometry counting methods usually employed in hospital laboratories. The counting efficiencies of C^{14}, Co^{60}, Sr^{90}/Y^{90}, I^{131}, Au^{198} and Tl^{204} have been determined by comparison with the Bureau's standards calibrated by 4π geometry and coincidence counting techniques, and the formamide method appears to provide an accurate yet very quick and satisfactory method of secondary standardisation. Experiments employing a 2π beta electroscope arrangement have also proved sufficiently precise for calibration purposes.

It is anticipated that the future of the radioactivity standardisation programme at the N.B.S. will be primarily concerned with the production of new domestic standards as the need arises. The expanded use of new nuclides in research, medicine and industrial production is indicative of how the demand for standardised samples and techniques will also grow. A movement is now in operation toward the standardisation of nuclides on an international basis and recently a Radioactive Isotopes Sub-Committee of the International Commission of Radiological Units has been established. Such a programme involves not only a direct comparison of the standards themselves but, especially in the case of short-lived nuclides, the establishment of comparable methods for the preservation of these standards in each of the countries involved.

Resistance-Wire Grid System for Measuring Plastic Strain

A RESISTANCE-WIRE grid system of mapping the deformations of a plate which has some kind of stress raiser and is stretched in its own plane is described in a report published in the April, 1955, issue of *The Trend in Engineering at the University of Washington*, by Professor D. D. Vasarhelyi. The principle of the method is to fix a high-resistance wire parallel to a gauge line on the plate: one end of the wire is solidly clamped to the end of the chosen gauge length while the other is attached to a fixture holding the wire in position. A slider is solidly fixed to the opposite end of the gauge length and is in contact with the wire. When the gauge length changes, as the plate is deformed, the length of the wire between the contacts changes simultaneously, and the voltage drop between the fixture and the sliding contact can be measured; this measurement can be done by connecting the wire in a Wheatstone bridge circuit. By passing one wire over a number of contacts at chosen gauge points the change in the distance between such points can be measured by alternately switching pairs of gauge points to the Wheatstone bridge or indicator.

A resistance wire grid of this kind has been used to cover areas of 36in by 18in and 48in by 24in in the study of plastic deformations of plate specimens. For this work a grid was designed with gauge lengths ranging from 1in to 4in. Some 130 gauge points were included and the elongation of about 220 grid lines was measured. The whole rig had to be suitable for insertion in a cooling bag and it had to function there throughout each test without intermediate checking.

The author of the report concludes, as a result of this work, that the operation of a slide-wire grid system presents no more difficulties than the operation of a large number of strain gauges. Readings can be taken fast enough to ensure practically continuous testing. The rig can readily be built with inexpensive, commercially-available materials and fittings and the whole equipment can be reused in a large number of tests.

Transcontinental Flight Speed Record

THE National Aeronautic Association has recognised as official the transcontinental Los Angeles to New York speed record established on March 9th by the U.S. Air Force in a Republic F-84F "Thunderstreak" and has raised the average speed attained from the 649 m.p.h., first announced to 652 m.p.h. The record broke the previous official record of 596 m.h.p. which was set in 1954 by Colonel Willard W. Millikan, Jr., in an F-86F "Sabrejet," by more than twenty minutes. Both flights originated at the Los Angeles International Airport and ended at Floyd Bennett Field, New York. Lieut.-Colonel Robert R. Scott, the commander of the 510th Squadron of the 405th Fighter Bomber Wing of the Tactical Air Command, of Langley Air Force Base, Virginia, flew the 2463·92 statute mile course between airports in 3 h 46 min 33 sec. When the N.A.A. adjusted the time to allow Scott credit for distance flown in reaching the Los Angeles Post Office—the official starting point—and the distance flown after passing Times Square in new York—the official finishing point—before he was clocked in at Floyd Bennett Field in Brooklyn, his flying time came down to 3 h 44 min 53 sec. The N.A.A. has forwarded official reports on the record-breaking performance to the Federation Aeronautique Internationale in Paris for an expected recognition as a "world class" record.

Industrial and Labour Notes

Work Study and the Trades Unions

The British Productivity Council has now published, in a pamphlet, summaries of the eight papers read at the work study conference which it held in London at the end of March. One of these papers, by Mr. Lewis Wright, a member of the general council of the Trades Union Congress, is entitled "Work Study and the Trades Unions." In this paper, Mr. Wright defines work study as "finding the easiest and most efficient way to do a job." It does not necessarily imply new equipment, he says, nor does it mean only time study. It involves, or should involve, everyone in the undertaking, both management and workers. It can make work easier for the worker, in terms both of physical labour and ease of mind, but it can, as experience has shown, the paper adds, also cause much unrest.

The paper goes on to say that it is not work study itself which engenders opposition, but the fear of its possible by-products of redundancy, changed status and the like. The experience of trade unionists, the paper continues, is that in too many cases the application of work study has resulted in jobs temporarily being lost. In Mr. Wright's view, it is not enough to point out that work study reduces labour costs and the cost of the product, thus stimulating demand and in the long run making for more jobs. Few workers, he says, are interested in the "long run," most live on weekly wages, and the idea of a long period of unemployment in order to create bigger and better jobs in the "sweet by-and-by" does not appeal. A plan to deal with possible redundancy is as important as the plan of work study itself, but, the paper suggests, this is not always considered, and represents a failure which has a retarding influence on the introduction of work study principles. Mr. Wright says also that status is an important consideration, for very often the application of work study breaks down the job so that fewer skilled operatives are needed.

Finally, Mr. Wright urges that there is plenty of room for co-operation between employers and trades unions, and says that whilst "it cannot be true that their interests are identical, there are a growing number of joint interests where co-operation is possible and desirable." If it appears that the trades unions too often act in the role of official opposition, Mr. Wright observes, "it is no bad thing so long as something constructive eventually emerges." Few employers imagine that any scheme can be arbitrarily imposed upon the workers, and most employers recognise that the trades unions have a point of view not always identical with their own. But, Mr. Wright claims, that is no reason why the two points of view should not ultimately be focused together.

European Community for Coal and Steel

On Tuesday last there opened in Strasbourg a meeting of the Common Assembly of the European Community for Coal and Steel. An early item on the agenda was the presentation of the High Authority's third annual report which reviews the Community's activities in the year ended April 10th last.

The section of the report which deals with market development says that the coal year 1954–55 began on a weak market which strengthened steadily under the influence of Europe's general economic expansion. Coking coal and coke, it is stated, are now once again short. The report explains that British coal imports influenced the Community directly, as orders for 5,000,000 tons were placed on the common market and swelled an already growing demand. An "indirect" influence, the report adds, was that imports of American coal into Britain raised the cost of shipping freights and, consequently, the cost of American coal to Community importers. About steel, the report says that output in the Community countries reached the record level last year of 43,800,000 metric tons. In the first quarter of this year, steel production in the Community countries was running at an annual rate of 50,000,000 tons. There are, it is commented, three factors which seem to be responsible for this boom, namely, stocks had fallen during the recession of 1953; consumers are buying products like cars, television sets and refrigerators in quantities hitherto unknown in Europe, and the heavy investment in industry, both in the Community and abroad, has boosted the demand for steel.

There is also reference in the report to investments. It is stated that from the United States' loan of 100 million dollars, the amounts lent to Community firms total 64·4 million dollars. Of the total, 23·3 million dollars have been devoted to the modernisation of collieries; 26·9 million dollars to power stations, and 14·2 million dollars to iron ore mines. In addition, a sum of 10,000,000 dollars has been earmarked for thermal power stations in Belgium. High Authority participation in financing these projects has varied between 20 and 30 per cent, the average being 22 per cent.

Mention is made in the report of the agreement completed in December last between the Community and the Government of the United Kingdom, the terms of which provide for the establishment of a Council of Association. At the beginning of this week, it was announced in London that the Foreign Secretary had appointed Mr. E. W. Meiklereid, of the British Embassy in Paris, to be head of the United Kingdom delegation to the High Authority. He succeeds Sir Cecil Weir, who has been leader of the delegation since August, 1952.

Employment and Unemployment

In its latest report on the employment situation in Great Britain, the Ministry of Labour says that during March the total working population declined by 35,000 and at the end of the month numbered 23,803,000 (16,055,000 men and 7,748,000 women). Of that total, there were 22,734,000 in civil employment during March, which was a net increase of 3000 over the preceding month.

An analysis of the civil employment figures for March reveals that 3,969,000 people were engaged in the basic industries. This was 9000 more than a month earlier, the increases being seasonal ones in transport and agriculture. There was no change in the extent of the coal mining labour force, the number of wage earners on colliery books at the end of March being returned as 708,000. In the manufacturing industries, 9,210,000 people were employed in March, indicating a drop of 6000 during the month. The decline occurred mainly in the textile trades, for in the "engineering, metal goods and precision instruments" group there was a further addition of 5000 to the labour force, bringing the total at the end of the month to 2,745,000, compared with 2,605,000 a year earlier. In vehicle manufacturing there was an addition of 1000 in March, making the total labour force 1,224,000. Outside the basic and manufacturing industries, the principal change was in building and contracting, where there was an addition of 2000 in March, bringing the number employed to 1,428,000.

The Ministry's latest unemployment returns show the position on April 18th, when 260,129 people were registered as out of work. This was 9782 fewer than on March 14th, and represented about 1·2 per cent of the total number of employees. The April figure included 33,801 who were reported to be temporarily stopped and 104,567 who had been unemployed for more than eight weeks.

Census of Production

The Board of Trade has announced that the census of production for the year 1956, which is to be taken in 1957, will be a simplified one computed on a "sample" basis. This decision is in line with the recommendations of the Verdon Smith committee on censuses of production and distribution. The statutory form for the larger establishments will be a simplified one and the questions to be answered will be identical with those put for the 1955 census. Smaller firms with fewer than eleven employees will be required to state only the nature of their business and the number of people employed, except in a few trades in which, because of their importance, some additional questions will be asked. The trades to be covered by the 1956 census of production will be mining and quarrying, the manufacturing industries, building and contracting, and the gas, electricity and water supply industries. Firms which are selected for inclusion in this sample census will be advised during the autumn of this year; they will receive an advance copy of the census form to enable them to arrange their records accordingly.

Cast Iron Scrap Prices

Following consultation with the Iron and Steel Board, the Minister of Supply has made an Order increasing the controlled prices of cast iron scrap in most areas. It is stated that these increases are designed to encourage the movement of cast iron scrap between areas in which there is a surplus and those which show a shortage. The increased prices, which came into effect on May 9th, have been agreed with the British Iron and Steel Federation, the Joint Iron Council and the National Federation of Scrap Iron, Steel and Metal Merchants.

Industrial Disputes and Arbitration

Before Parliament was prorogued at the end of last week, the Parliamentary Secretary to the Ministry of Labour, Mr. Harold Watkinson, answered questions about the methods of settling industrial disputes. He said that arbitration proceedings aimed to provide a peaceful means for the settlement of differences rather than to bring stoppages of work to an end.

Mr. Watkinson went on to say that from the beginning of 1952 till the end of April this year, 1019 awards were issued by arbitration bodies appointed by the Minister of Labour. In the same period, ten reports of courts of inquiry and six reports of committees of investigation were made in connection with actual or threatened disputes, and helped to promote a settlement. Statistics of stoppages ended through voluntary negotiating machinery were not available, Mr. Watkinson said, but a very large number were averted or brought to an end by negotiations between the parties, with or without the assistance of the Ministry's conciliation officers.

In another question it was suggested that, if the working of arbitration tribunals could be expedited, recourse to other forms of arbitration would not be quite so necessary. Mr. Watkinson said that was a very practical suggestion. Where possible, his Ministry expedited matters, but, he commented, "it was not always possible."

Coal Production

Coal production last week amounted to 3,960,700 tons, compared with 4,581,900 tons in the preceding week and 4,440,300 tons in the corresponding week of last year. Last week's output from the deep mines, amounting to 3,739,900 tons, was seriously reduced by an unofficial strike in the Yorkshire coalfield. The strike began three weeks ago, at the Markham Main pit, over a dispute concerning rates of pay for fillers, and last week spread to other places in Yorkshire. The strike has been condemned by the National Coal Board and the National Union of Mineworkers as "unjustified and unnecessary," and it has been emphasised that the matters in dispute can be dealt with through the accepted conciliation machinery. At the time of going to press, there was no indication of a general return to work. Meanwhile, the National Coal Board has said that already this year the country has lost 1,000,000 tons of coal through unofficial strikes, at a time when large quantities of coal are being imported to keep industry going.

Personal and Business

Appointments

COMPOFLEX COMPANY, Ltd., announces the appointment of Mr. J. C. Franks as an additional representative in the Midlands.

MR. J. R. DUFF, A.M.I.Mech.E., has been appointed works manager of Blackburn (Dumbarton), Ltd., in succession to Mr. L. Maxwell.

MR. N. R. CRUMP has been elected president of the Canadian Pacific Railway Company. Mr. R. H. McMaster has been elected vice-president.

MR. C. F. B. HIPPISLEY has been appointed London sales manager of Brown, Lenox and Co., Ltd., 157, Victoria Street, S.W.1 (telephone, Tate Gallery 9227).

SIR EDWARD CHADWYCK-HEALEY, Bt., has been elected president of the London Chamber of Commerce, in succession to Lord Luke, who has served for three consecutive years.

THE BRITISH THOMSON-HOUSTON CO., Ltd., announces the appointment of Mr. A. B. Frost as manager of the Northampton lamp depot in succession to Mr. F. E. Perry.

THE MINISTER OF TRANSPORT AND CIVIL AVIATION states that Mr. T. H. Summerson, Sir Cecil Weir, and Mr. F. A. Pope have been appointed part-time members of the British Transport Commission.

THE BRITISH TRANSPORT COMMISSION announces the following appointments to the central staff of British Railways: Mr. E. G. Brentnall, assistant signal engineering officer; Mr. D. F. Gowen, staff officer.

MR. T. A. CROWE, M.I.Mech.E., has been elected chairman of North British Locomotive Company, Ltd. He succeeds Mr. J. B. Mavor, M.I.Mech.E., who has relinquished the appointment for health reasons.

RHODES, BRYDON AND YOUATT, Ltd., Stockport, states that Mr. M. A. Graham has been appointed sole technical representative in Northern Ireland. His address is 10, Brunswick Street, Belfast (telephone, Belfast 29087).

C. A. PARSONS AND COMPANY, Ltd., Heaton Works, Newcastle upon Tyne, 6, states that Dr. A. T. Bowden, chief research engineer, has been elected a director. Mr. A. McLean has retired from the board of the company.

THE LONDON DIVISION OF THE CENTRAL ELECTRICITY AUTHORITY announces the appointment of Mr. R. W. Bassil, A.M.I.E.E., as superintendent at the Deptford West generating station, in succession to Mr. G. H. Whelton, who is retiring.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., states that Mr. H. G. Harlow, M.I.E.E., has been appointed manager of the Newcastle upon Tyne district office. He is succeeded as manager of the Leeds office by Mr. W. J. Wilson, A.M.I.E.E.

MR. J. R. C. BOYCE, of British Oil Burners, Ltd., has been re-elected president of the British Oil Burner Manufacturers Association. Mr. J. D. Fitzgerald, of Combustions, Ltd., and Mr. F. C. Pillinger, of G. C. Pillinger and Co., Ltd., have been re-elected vice-presidents.

MR. H. T. RAMSAY, M.I.E.E., has been appointed director of the Safety in Mines Research Establishment of the Ministry of Fuel and Power. He succeeds Mr. A. H. A. Wynn, who has relinquished the appointment on becoming a member of the National Coal Board.

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION states that Mr. J. Graham has been appointed principal officer of the N.E. England district of the marine survey service, in succession to Mr. F. Rae, who is retiring. Mr. Graham has been senior engineer and shop surveyor in the consultative branch of the service since 1947.

MR. A. N. BUTLAND, A.M.I.C.E., has been appointed assistant civil engineer in the London Midland region of British Railways. Mr. Butland began his railway career, in 1924, on the staff of the chief engineer, Great Western Railway. Since 1952 he has been assistant civil engineer in the North Eastern region of British Railways.

MR. A. F. BURKE has been elected chairman of the de Havilland Engine Company, Ltd., in succession to the late Major F. B. Halford. Mr. Burke joined the company in November, 1944, as a director and general manager, and has been managing director since 1948, which position he will continue to hold. He is also a director of the de Havilland Aircraft Company, Ltd.

SHEEPBRIDGE ENGINEERING, Ltd., announces the appointment of Mr. W. Hamilton as sales manager of the engineering division of Sheepbridge Equipment, Ltd. Mr. A. A. Harding has been appointed welfare manager of Sheepbridge Engineering, Ltd. Mr. W. J. Rickard has been appointed Midlands area engineer of Twiflex Couplings, Ltd., another Sheepbridge subsidiary.

METROPOLITAN-VICKERS ELECTRICAL CO., Ltd., Trafford Park, Manchester, announces the appointment of Mr. C. Ryder, M.I.E.E., as chief engineer, instrument and meter department, in succession to Mr. T. W. Ross, M.I.E.E., who has become consultant to the company's chief electrical engineer. Mr. J. C. Dawson, A.M.I.E.E., has been appointed assistant sales manager in the switchgear department.

TUBE INVESTMENTS, Ltd., states that Dr. F. P. Bowden, F.R.S., of Cambridge University, has been appointed chief research consultant at the research laboratories at Hinxton Hall, Cambridge. The following have been appointed research scientists at the laboratories: Dr. A. Charlesby, Mr. J. E. Gordon, Mr. A. P. Green, Dr. R. J. W. McLaughlin, Dr. J. W. Menter, Dr. D. W. Pashley, Dr. G. W. Rowe, and Mr. R. Worrall.

ENGINEER-CAPTAIN G. VILLAR, R.N.(ret.), a director and general manager of John I. Thornycroft and Co., Ltd., Southampton, has been elected chairman of the Dry Dock Owners and Repairers Central Council. Mr. P. Gifford, a director of D. and W. Henderson, Ltd., has been elected senior vice-chairman, and Lieut. Colonel T. Eustace Smith, managing director of Smith's Dock Co., Ltd., has been elected junior vice-chairman.

Business Announcements

GEORGE SALTER AND CO., Ltd., West Bromwich, states that its telephone number has been changed to West Bromwich 1855.

THE ZINC DEVELOPMENT ASSOCIATION, and its affiliated societies, have moved their offices from Oxford to 34, Berkeley Square, London, W.1 (telephone, Grosvenor 6636).

J. BLAKEBOROUGH AND SONS, Ltd., Brighouse, Yorks, announces the retirement, owing to ill health, of Mr. Harry Tart, M.I.Mech.E., production engineer. Mr. Tart has been in the service of the firm for fifty years.

GEORGE FISCHER, Ltd., Schaffhausen, Switzerland, states that its sole selling agent in the United Kingdom for "GF" copying lathes is now Vaughan Associates, Ltd., 4, Queen Street, Curzon Street, London, W.1 (telephone, Grosvenor 1571).

WOLSELEY ENGINEERING, Ltd., is the new title of the firm hitherto known as the Wolseley Sheep Shearing Machine Company, Ltd. Its works remain at Electric Avenue, Witton, Birmingham, 6, and there is no change in the management of the company.

THE GENERAL ELECTRIC COMPANY, Ltd., has opened new branch premises at Great Western Road, Gloucester. The company has also announced that it has completed the purchase of 99 per cent of the shares of Amalgamated Electric Corporation, Ltd., of Toronto.

MR. L. H. A. CARR, M.I.E.E., has retired from the staff of Metropolitan-Vickers Electrical Company, Ltd. He joined the firm in 1920, and since 1943 has held the position of consulting engineer (patents). Mr. Carr has been a part-time lecturer at the Manchester College of Technology for over twenty years, and is a member of the Court of Governors of Manchester University.

Contracts

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has received an order, valued at over 1,000,000 dollars, from the Manitoba Hydro-Electric Board (Canada) for the supply of the third and fourth 33MW single-cylinder turbo-generator sets for the power station at Brandon, near Winnipeg. The first two sets for this station were ordered from the same company in 1954. Each turbo-generator set for Brandon will run at 3600 r.p.m. and will incorporate single-cylinder turbines designed for a maximum rated output of 33,000kW, the largest output of any single-cylinder machines yet built by Metropolitan-Vickers: the initial steam conditions are 600 lb per square inch gauge and 825 deg. Fah. exhausting to condenser at 28in Hg. The generators will be 13kV hydrogen cooled machines using gas at a pressure of ½ lb per square inch.

Miscellanea

MR. J. S. HAMPTON.—We have learned with regret of the death, on May 5th, of Mr. J. Sidney Hampton, director and general manager of Davy and United Roll Foundry, Ltd., Empire Works, Haverton Hill, Co. Durham.

IMPORTS OF BENTONITE CLAY.—The Board of Trade announces that bentonite, a clay used in steel casting and paint manufacture, can now be imported from all countries without individual import licences. Imports from dollar sources have hitherto been subject to licensing control.

SCHOLARSHIPS IN INDUSTRIAL RELATIONS.—The National Coal Board is introducing a new scheme for "industrial relations" scholarships. Four such scholarships, tenable either at Ruskin College or a university, are being offered this year to mineworkers with not less than five years' underground experience. The courses, in the social sciences, will lead to either a degree or a diploma. The scholarships are intended to train men for labour relations work in the industry. They are worth about the same as State scholarships and there are additional allowances for married men.

LUBRICATION.—The Petroleum Information Bureau has published a memorandum on lubrication, which states that the study of the science of lubrication and the evolution of lubricants has been a major contribution to the development of modern machinery. The memorandum broadly considers the history and principles of lubrication and the kind and sources of lubricants, and goes on to discuss the manufacture, application and uses of lubricating oils and of lubricating greases, concluding with a note on testing and research. Copies of the memorandum may be obtained free from the Petroleum Information Bureau, 29, New Bond Street, London, W.1.

EXTENSION SPRAY GUNS.—In product finishing and constructional work a demand frequently arises for a spray gun which can apply a coat of material to a surface impossible to reach with a standard gun. To meet this requirement B.E.N. Patents, Ltd., High Wycombe, Bucks, has introduced some new extension spray guns which have a selection of extension tubes of varying lengths up to 10ft and nozzle settings to suit a number of applications. Amongst the nozzle arrangements available are set-ups to provide angular, straight, flat circular and reverse sprays. These guns can be used in restricted positions, for coating the interior of pipes with bituminous compounds and for painting pipework on electrical transformers, tubular boilers, radiators and similar equipment.

MOTOR INDUSTRY SCHOLARSHIPS.—The Institute of the Motor Industry states that it is responsible for awarding several scholarships of £150 per annum, tenable for four years at the College of Technology, Loughborough. These awards will be made to suitable candidates before June 30th. Young people possessing the General Certificate of Education at ordinary level, who wish to avail themselves of the facilities offered by the diploma course, should make application in the first place to the Registrar, The College of Technology, Loughborough. If they are accepted by the College they will then become eligible for a scholarship award. These scholarships are open not only to students leaving school, but are also available to suitable young people already engaged in the motor industry.

ROAD CASUALTIES.—Over 16,500 people were injured on the roads of Great Britain in March, 352 of them fatally. Serious injuries are provisionally reported to have numbered 3756 and slight injuries 12,399. A marked increase in accidents to motorists and their passengers is shown by the detailed figures for February. The number of those killed and injured in these accidents was 8175, or 1374 more than in February, 1954. Casualties among motor-cyclists and their passengers increased by 327, and those among occupants of other motor vehicles by 1052. But casualties among motor-assisted pedal cyclists, numbering 165, fell by five. The continued rise in road casualty figures, particularly those for drivers and passengers, has coincided with the rapid growth in the number of motor vehicles on the road, which last year increased by nearly half a million. During February bad weather created additional risks. Casualties to all road users in February totalled 14,524. This was 1654 more than in February, 1954, and included 309 deaths, an increase of forty-three.

BRITISH ELECTRICAL DEVELOPMENT ASSOCIATION.—The British Electrical Development Association held its annual luncheon at the Savoy Hotel, London, last Tuesday, with the president, Sir John Hacking, in the chair. The principal speaker was Earl Jowitt, P.C., who commented upon the rapid development of the electrical industry during the years since the formation of the Association in 1919. He mentioned that the value of this country's electrical exports last year was £218million and said that it was also impressive to remember that between 1919 and 1954 the number of consumers of electricity had risen from 1,000,000 to 14,500,000. Lord Jowitt added that this country had led the world in the steam age and in the electrical age. It was essential that Britain should maintain her lead in the development of nuclear power for peaceful purposes. The president proposed a toast to "The Guests," the response being made by the Hon. L. W. Joynson-Hicks, Parliamentary Secretary to the Ministry of Fuel and Power. At the annual meeting of the Association, which followed the luncheon, Viscount Chandos was elected president for 1955–56, and Mr. Thomas Johnston, C.H., and Lord Hurcomb were elected vice-presidents.

British Patent Specifications

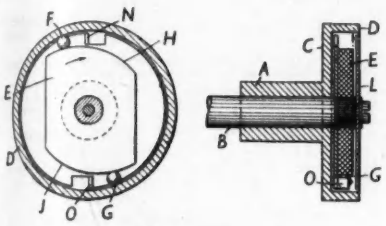
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

POWER TRANSMISSION

727,855. April 24, 1953.—ONE-WAY COUPLINGS, Haldex Aktiebolag, 9, Knäredsgatan 9, Halmsted, Sweden.

The invention is intended to simplify couplings by reducing the number of movable parts to a minimum. The coupling shown in the drawing is



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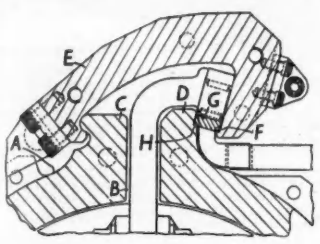
intended for coupling two coaxial shafts to one another, one shaft *A* being hollow and formed as a bearing for the other shaft *B*. The coupling member secured to the shaft *A* consists of a disc *C* having an annular flange *D*, while the coupling member secured to the shaft *B* consists of a disc-shaped permanent magnet *E*, which is forced on to a grooved end of the shaft. As shown, the locking members consist of two balls *F* and *G*, which on a rotary movement in one direction are tightly jammed into frictional engagement between the inner cylindrical surface of the flange *D* and opposed edge surfaces *H* and *J*, respectively, of the coupling member *F*. The edge surfaces are shaped so that the locking members are operative only on a rotary movement in one direction while being released on a rotary movement in the opposite direction. The balls are retained in their places between the two coupling members and by ball holders consisting of an inner plate secured to the shaft *B* and an outer covering plate *L*, which is screwed into the end of the shaft. The inner plate is provided with two lobes *N* and *O* cut from the edge portion of the plate and bent axially outwards. These lobes limit in one direction the space which is closest to the respective ball between the two coupling members. Modified designs are also shown in the specification.—*April* 6, 1955.

728,120. February 28, 1952.—CYLINDER AND PISTON CONSTRUCTION, Brown Brothers and Co., Ltd., Rosebank Ironworks, Edinburgh, 7; and Colin Campbell Mitchell, of 26, Clermiston Road, Edinburgh, 12.

The invention relates to a cylinder and piston construction and is a development of the construction described in the Specification No. 640,622, which described a cylinder, the wall of which is formed with a longitudinal slot. In the drawing *A* is a cylinder



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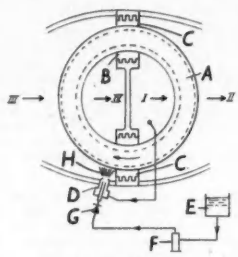
formed with a longitudinal slot *B*, the marginal portions of the wall of the cylinder bounding the slot presenting longitudinal flanges *C*, *D* and *E* forming a clamp member substantially of "*C*" shape in cross-section. One of the clamp horns engages the flange *C* and the other horn is checked at *F* to engage one edge of a flexible sealing strip *G*, the other edge of which engages a check *H* in the flange *D*, the sealing strip being inclined at an acute angle to a plane containing the axis of the cylinder and passing through the centre of the slot. In practice, fluid under pressure within the cylinder tends to move the clamp member *E* radially away from the cylinder. Such radial force may be resolved into two components, the direction of one of which is transversely to the sealing strip. The reaction offered by the sealing strip to the transverse component has a component equal and opposite to the radial force and resists the tendency for the clamp member *E* to move radially away from the cylinder. The resistance of the cylinder to bursting is thus maintained despite the longitudinal slot *B*, since the clamp member *E*, acting through the strip *G*, grips the faces of the upstanding flanges *C* and *D* and prevents these flanges from moving away from one another.—*April* 13, 1955.

GAS TURBINES

727,973. September 3, 1951.—COMBUSTION TURBINE REGENERATOR SEALS, C. A. Parsons and Co., Ltd., Heaton Works, Newcastle upon Tyne, 6. (*Inventor: Max Bentele.*)

The invention relates to combustion turbine rotary regenerator seals and more specifically to the lubrication of their contact seals. In carrying the invention into effect in the form illustrated in the drawing cold high-pressure air entering the regenerator at *I* is preheated by a matrix and leaves at an exit *II*. Hot low-pressure gas entering at an inlet *III* is cooled by



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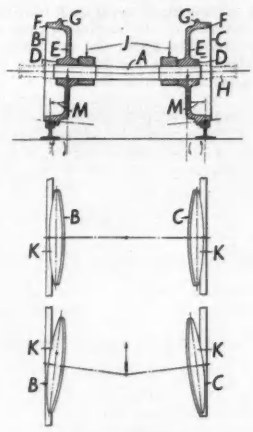
the matrix and leaves at exit *IV*. The high-pressure side and the low-pressure side are sealed along the inner surface of the regenerator rotor *A* by shoes *B* and along the outer surfaces by other shoes *C*. The outer surfaces of the rotor or parts thereof are sprayed with the lubricant by an atomiser *D*, which is positioned on the low-pressure side close to the trailing edge of the shoe where the rotor enters the low-pressure side. A diluted dispersion of the lubricant is stored in a tank *E* and conveyed to the atomiser by an intermittently operated injection pump *F* by way of a non-return valve *G*. In the atomiser arrangement air drawn from the cold high-pressure inlet *I* cools the atomiser and is given a vortex motion by a swirler. It ejects the dilution which is delivered by pump *F* and atomises it to a spray *H*. The diluent evaporates or burns, or both, in the hot gas, and the lubricant is deposited on the rotor face, the film being dry when it reaches the next seal. When delivery from the pump ceases the non-return valve *G* closes and the remainder of the dilution inside the nozzle is also ejected by the air. Evaporation of the dilution inside the atomiser, which would result in depositing the lubricant on the walls and clogging of the passage, is thus prevented.—*April* 13, 1955.

RAILWAY ENGINEERING

727,997. August 6, 1952.—WHEEL AND AXLE ASSEMBLY, The United States Steel Corporation, 525, William Penn Place, Pittsburgh 30, State of Pennsylvania, U.S.A.

The invention relates to a load-carrying wheel and axle assembly for railway vehicles, the object being to provide an assembly for carrying a load on a pair of spaced rails by which the weaving effect and wear of the wheels is greatly reduced. Referring to the drawing, the assembly consists of an axle *A* on which are mounted identical wheels *B* and *C*. Each of the wheels consists of a hub *D*, radial web *E*, tread portion *F*, and a flange *G*. The webs *E* are sufficiently flexible so that they can give slightly under load. The tread *F* is preferably tapered axially outwards and the operation of the device is as follows:—When the car is not moving the wheels will assume the position shown in the centre view. In this position it will be seen that each plane *K* of each wheel tilts inwardly at the top toward the other wheel. In order to accomplish this it is necessary that the web *E* be located in a plane between the rails. By locating the load supports *J* between the hubs, as shown in full lines in the upper view, the axle will bend down in the centre. The deflections are caused by the forces produced by couples indicated. The couple arm *M* need not be as large as shown. When the car travels in the direction of the arrow of the lower view the planes *K*, leaning inwards as they do, create a banking tendency causing the wheels to tend to roll in a path curved in towards the centre of the track. The tilting action of the wheels in both directions is greatly exaggerated for the purpose of illustration, it being understood that a very slight amount of deflection or tilt such as a few thousandths of an inch is all that is required. Because of this action there is a tendency for the wheels at all times to move toward each other while rotating. This creates constant lateral inwardly opposed forces at the line of wheel contact with the rails, thus tending to centre



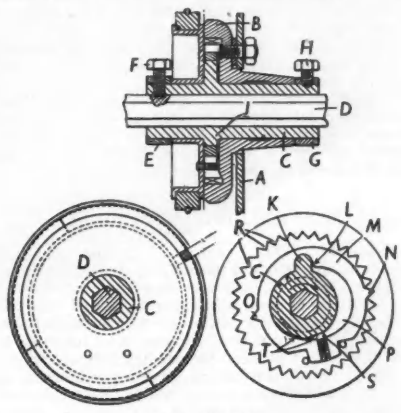
No. 727,997

the load automatically between rails. This greatly diminishes the amount of weave and provides a much smoother ride. Modified constructions are also shown in the specification.—*April* 13, 1955.

AGRICULTURAL ENGINEERING

727,955. July 29, 1953.—FREE WHEEL UNITS, Barford (Agricultural), Ltd., Grantham, Lincolnshire. (*Inventors: Thomas Arthur Hill and John Phillip Bass.*)

The invention relates to a free wheel and its object is to provide a device which is so constructed that the ground wheel fitted with the unit can be power driven in either a forward or reverse direction with the wheel able to overrun or "free wheel" in either direction. Referring to the drawing, the wheels of the implement each comprise a disc *A*, which is bolted to a free wheel housing *B* mounted to rotate freely on a sleeve *C* which is carried and rotated by an axle *D*. As shown in the drawings, it is convenient to make the axle of hexagonal or other polygonal cross-section and to provide the sleeve with a corresponding bore. The sleeve is fitted at one end with a stop collar *E*, secured by means of a set screw *F* to hold the sleeve against axial displacement.



No. 727,955

The other end of the sleeve is fitted with a stop collar *G* secured to the sleeve by a set screw *H*. The sleeve *C* constitutes a rotary driving member which is coaxially mounted within the housing *B* and driven by the wheel axle *D* and this sleeve is formed or fitted between its ends with a flange or disc *J* formed with a lobe *K* which engages in a recess *L* formed in an annular transmission member *M* disposed between the driving member *C* and the housing *B*. The transmission member *M* is formed with a pair of opposite teeth *N* and *O* and also with an oval opening *P* having a major axis larger than the diameter of the flange *J* of the driving sleeve so as to permit the member to be moved relatively to the sleeve and the housing *B*. Such a movement serves to disengage one of the teeth *N* or *O* from, and to engage the other with, a ring of teeth *R* formed in the free wheel housing *B* whereby a reverse or forward drive of the housing and hence the wheel is obtained. In either of its two driving positions the operative tooth *N* or *O* is capable of being overrun by the teeth on the housing to permit one wheel on the axle to rotate faster than the other during cornering, the transmission member

M yielding when its tooth is pushed out by the teeth *R*. In order to permit the member *M* to move and yield to any overrunning action of the housing the tail portion is constructed to accommodate a resiliently yieldable means in the form of a spring-loaded plunger *S* which co-acts with one of two flats *T* on the flange *J*, the arrangement being such that the plunger under the influence of its loading spring presses on the engaged flat *T* to move the tail away from the flat and thereby causes the tooth *N* or *O* to snap back into engagement with the teeth *R*. It will be noticed that the spring-loaded plunger *S* acts to one side of a dead centre passing between the two flats *T*, one flat being used for forward drive and one for reverse. Any suitable control may be provided for reversing the drive to the axle.—*April* 13, 1955.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

COMPONENTS OF CRAWLER TRACTORS AND EARTH-MOVING EQUIPMENT

No. 2596 : 1955. Price 4s. This standard is divided into two parts as follows :—

Part 1 is intended primarily for crawler tractors for industrial use. It includes features covering the mounting of equipment, such as cable control units and heavy duty winches ; classification for three classes of tractors ; requirements for power take-off and tractor drawbars, and a method for describing the tractor gauge and the width of track plates.

Part 2 deals with scrapers and dozers and specifies requirements for cutting edges, cable wedges, wire ropes, &c. For the scraper, a method of determining size and yardage rating and a method of calculating dig and depth of spread are included. For the dozer, definitions are given for side-casting angle, tilt and pitch.

The standard does not aim to standardise design or to restrict development. It specifies those requirements which will secure a measure of interchangeability, where this is necessary ; gives definitions where required to avoid ambiguity, and specifies standard methods of rating equipment. The standard recommends that manufacturers should adopt the unified screw thread and hexagons on all future designs.

SQUARE NUT SPANNERS (POST OFFICE TYPE)

No. 2575 : 1955. Price 2s. The square nut spanners in this specification have the general appearance of the type specified in B.S. 192 : " Open-ended Spanners." Their proportions and dimensions, however, are slightly different, and they are intended for the square nuts fitted to the old style Whitworth bolts.

These are the spanners used by the Post Office authorities, electricity authorities, and such-like bodies, on their outdoor equipment. The nuts are subject to varying weather conditions and for this reason the spanners must be robust.

SPOT WELDING ELECTRODES

No. 807 : 1955. Price 3s. The previous edition of this standard related only to shanks of spot welding electrodes, and was issued to ensure interchangeability of electrodes in the sockets of electrode holders. The present edition covers the standardisation of the electrode tips, with particular reference to the relationship between the welding surface and the holder. The dimensions have been standardised on the basis of common usage to facilitate the production of electrodes. Electrodes of the vertical centre, vertical off-set, angle off-set and crank off-set types are included, for sizes of $\frac{1}{4}$in, $\frac{1}{2}$in, $\frac{3}{4}$in, $\frac{7}{8}$in, 1in, and $1\frac{1}{4}$in, with the exception of the crank off-set electrode for which only $1\frac{1}{4}$in size is given. A preference, however, is shown for $\frac{1}{4}$in electrodes.

ROTARY DRILL RODS AND TUNGSTEN CARBIDE TIPPED ROTARY DRILL BITS FOR DRY DRILLING

No. 2593 : 1955. Price 2s. 6d. This new standard forms one of a series which it is intended to prepare for the mining and quarrying industries where cutting equipment of a kind common to both is in use. The present standard covers rotary drill rods and tungsten carbide tipped rotary drill bits for dry drilling and specifies requirements for the shank of the rod, the size and positioning of the slot into which the bit is fitted, and a tolerance for rod straightness. The sizes for shank and depth of shoulder are given for seven diameters of bit. The standard is intended to provide interchangeability between the drill rod, the drill spindle socket, and the bits, and to reduce as far as is consistent with efficiency the number of different types at present in use. Consideration was given to including a specification for materials for the rods, but, in view of developments being undertaken at the present time, detailed requirements for materials have been omitted from this edition of the standard.

Launches and Trial Trips

OSPREY, light vessel : built by Philip and Son, Ltd., for the Commissioners of Irish Lights for the South Rock station ; length overall 136ft 5in, beam 25ft, depth moulded 15ft ; lantern with 10 miles range, four 4$\frac{1}{2}$kW diesel-driven generators, two diesel-driven air compressors, 4-ton mushroom anchor, air-driven windlass. Launch, April 22nd.

WESTERN PRINCE, cargo ship ; built at the Govan yard of Harland and Wolff, Ltd., for the Prince Line, Ltd.; length between perpendiculars 435ft, breadth moulded 61ft, depth moulded to shelter deck 38ft 6in, deadweight 10,000 tons on 27ft 6in draught ; 7900 tons gross ; two continuous decks, five holds, one 50-ton, four 10-ton and twelve 5-ton derricks, steam deck machinery ; three 50kW steam-driven generators ; Harland and Wolff single-acting, two-cycle, opposed-piston oil engine, five cylinders, 750mm diameter by 2000mm combined stroke, 110 r.p.m. Trial, April 28th.

SUGAR IMPORTER, bulk sugar carrier ; built by Hall, Russell and Co., Ltd., for Silvertown Services, Ltd.; length overall 353ft 9in, length between perpendiculars 330ft, breadth moulded 50ft, depth moulded 26ft 6in, 5250 tons deadweight on 22ft 2in draught loaded ; single deck, four holds, electric deck machinery ; two British Polar diesel engines, each 1520 b.h.p. at 300 r.p.m., each engine coupled through hydraulic couplings and reduction gearing to drive a single shaft at 150 r.p.m. Launch, May 5th.

VIBEX, oil tanker ; built by Harland and Wolff, Ltd., at Belfast, for Shell Tankers, Ltd.; length between perpendiculars 635ft, breadth moulded 84ft 3in, depth moulded 46ft 3in, deadweight 31,000 tons ; thirty cargo oil tanks, one main cargo pump room, steam-driven pumps and deck machinery ; two 550kW turbo-alternators, one 150kW diesel-driven alternator ; one set of double-reduction geared turbines, 13,000 s.h.p. at 105 propeller r.p.m., steam supplied at 600 lb per square inch and 850 deg. Fah. Launch, May 5th.

THISTLEDHU, cargo ship ; built by John Crown and Sons, Ltd., for the Albyn Line, Ltd.; length between perpendiculars 420ft, breadth moulded 59ft 6in, depth moulded 38ft, deadweight 10,000 tons on 26ft draught ; five holds, derricks to lift 7 tons and 10 tons, steam deck machinery ; service speed 14 knots ; Doxford opposed-piston oil engine, four cylinders, 670mm diameter by 2320mm combined stroke. Launch, May 6th.

SARAH BOWATER, newsprint carrier ; built by William Denny and Brothers, Ltd., for the Bowater Paper Corporation, Ltd.; length overall 419ft, breadth 58ft 6in, depth 35ft 6in, deadweight 8400 tons on 26ft 6in loaded draught ; four cargo holds, six hatchways, fourteen 5-ton and two 10-ton derricks, steam deck machinery, service speed 14 knots ; one set of Parsons single-reduction geared turbines, steam supplied at 250 lb per square inch and 650 deg. Fah. by two Foster-Wheeler boilers. Launch, May 6th.

SIDERURGICA VI, collier ; built by the Forges et Chantiers de la Gironde for the Cie Siderurgica Nacional, Rio de Janeiro ; length overall 474ft 1in, length between perpendiculars 441ft 6$\frac{1}{2}$in, breadth moulded 57ft, depth to upper deck 37ft 4in, draught loaded 27ft 9in, displacement 15,800 tons, deadweight 11,680 tons, service speed 12 knots, machinery constructed by the Ateliers et Chantiers de France, one reciprocating steam engine, 3700 h.p., four oil burning cylindrical boilers supply steam at 225 lb per square inch. Trial, May.

Catalogues

B.E.N. PATENTS, Ltd., High Wycombe, Bucks. B.E.N. catalogue C.B.111, Compressed Air Equipment.

DAVEY PAXMAN AND CO., Ltd., Colchester.—Publication 1375R., " Diesel Engines for Rail Traction."

SANDERSON BROTHERS AND NEWBOULD, Ltd., Newhall Road, Sheffield.—Folder M.E.15, " Machine Knives."

THE BRITISH APPLIANCES MFG. COMPANY, Ltd., Longclose Works, Dolly Lane, Leeds, 9.—Booklet on expansion pieces.

BLAW KNOX, Ltd., 90-94, Brompton Road, London, S.W.3.—Catalogue illustrating the use of steel forms in a variety of constructional projects.

REFRIGERATOR COMPONENTS, Ltd., 1 and 2, Greycoat Place, Westminster, London, S.W.1.—Descriptive bulletin of " packless " refrigerant shut-off valves.

PINCHIN JOHNSON AND CO., 4, Carlton Gardens, London, S.W.1.—Publication dealing with electrical insulating varnishes, enamels and compounds.

ELLIOTT BROTHERS (LONDON), Ltd., Century Works, Lewisham, London, S.E.13.—Leaflet on Elliott-Bristol's instrumentation for gas and water engineering.

CHARLES WESTON AND CO., Ltd., Irwell Bank Works, Douglas Green, Pendleton, Salford, 6.—Catalogue covering the standard range of Weston oil seals.

THE ALDRIDGE TOOL AND ENGINEERING COMPANY, Ltd., Whetstone Works, Aldridge, Near Walsall, Staffs. —Details of the Aldridge heat treatment service.

THE BENJAMIN ELECTRIC, Ltd., Tottenham, London, N.17.—Outdoor catalogue No. 2520, describing and illustrating Benjamin fittings for outdoor lighting.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., May 18th.—LONDON SECTION : School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, " The Development of the Underwater Television Camera," D. R. Coleman, D. A. Aliianson and B. A. Horlock, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

Tues., May 17th.—S. WALES BRANCH : S. Wales Engineering Institute, Park Place, Cardiff, Ten-Minute Talks and Discussions by Branch Members, 7.15 p.m.

Wed., May 18th.—KENT BRANCH : Bull Hotel, Rochester, Discussion Evening, 7 p.m.

Thurs., May 19th.—BLACKBURN BRANCH : Golden Lion Hotel, Blackburn, " Cotton Spinning Machinery," W. A. Hunter, 7.30 .pm.

Thurs., May 26th.—SHEFFIELD AND DISTRICT BRANCH : Grand Hotel, Sheffield, " Illumination," 7.30 p.m.

Fri., May 27th.—BIRMINGHAM BRANCH : Imperial Hotel, Birmingham, " Steam in Industry," L. A. Bawden, 7.30 p.m.

INSTITUTE OF INDUSTRIAL ADMINISTRATION

Wed., May 25th.—LONDON BRANCH : Fyvie Hall, The Polytechnic, Regent Street, London, W.1, " The Practice of General Management : Application of Scientific Research," A. King, 6.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., May 16th.—STUDENT LECTURE : 85, Minories, London, E.C.3, " Electrical Auxiliaries," J. W. Davidson, 6.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., May 24th.—SPECIAL MEETING : Royal Institution, 21, Albemarle Street, Piccadilly, London, W.1, " Mechanism of Fluidization of Powders in Gases," Warren K. Lewis, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., May 17th.—ROAD MEETING : Great George Street, Westminster, London, S.W.1, " Working Capacity of Roads," A. J. H. Clayton, 5.30 p.m.

Thurs., May 19th.—WORKS MEETING : Great George Street, Westminster, London, S.W.1, " The Use of Explosives for Demolitions," D. H. Brook and R. Westwater, 5.30 p.m.

Tues., May 24th.—ORDINARY MEETING : Great George Street, Westminster, London, S.W.1, James Forrest Lecture : " Nuclear Power and World Energy Resources." Sir John Cockcroft, 5.30 p.m.

Tues., June 7th.—Great George Street, Westminster, London, S.W.1, Annual General Meeting, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., May 16th.—LONDON STUDENTS' SECTION : Savoy Place, London, W.C.2, Annual General Meeting, to be followed by a Film Show, 6.30 p.m.

Tues., May 17th.—EDUCATION DISCUSSION CIRCLE : Savoy Place, London, W.C.2, Questions Night, 6 p.m.

Wed., May 18th.—SUPPLY SECTION : Savoy Place, London, W.C.2, " The Supply of Electricity in the London Area," D. H. Irving, 5.30 p.m.

Thurs., May 19th.—ANNUAL GENERAL MEETING : Savoy Place, London, W.C.2, Corporate Members and Associates only, followed at 6.30 p.m. by " Human Relations in Industry," The Rt. Hon. Lord Citrine.

INSTITUTION OF ENGINEERING DESIGNERS

To-day, May 13th.—N.E. BRANCH : Crown Hotel, Clayton Street, Newcastle upon Tyne, Annual General Meeting, 6.15 p.m.; Annual Dinner, 7.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, May 13th.—GENERAL MEETING, HYDRAULICS GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, " An Investigation of Hydraulic Lock," J. Manhajm and D. C. Sweeney, 6.45 p.m.

Sat., May 14th.—S. WALES BRANCH : Visit to Bridgend Paper Mills, 10.15 a.m.

Wed., May 18th.—LONDON GRADUATES' SECTION : 1 Birdcage Walk, Westminster, London, S.W.1, Annual General Meeting, " Servo Control," P. J. Bhatt, followed by Discussion, 6.30 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., May 26th.—Geological Society, Burlington House, Piccadilly, London, W.1, Annual General Meeting (Corporate and Non-Corporate Members only), 4 p.m.; Presentation of Awards, Induction of New President, Stanley Robson, Presidential Address, 5.15 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., May 25th.—SHREWSBURY SECTION : Technical College, Shrewsbury, " Manufacture of Springs," J. A. Roberts, 7.30 p.m.——WOLVERHAMPTON SECTION : Technical College, Wolverhampton, " Practical Approach to Engineering Fine Surfaces," D. B. Ebsworth, 7.15 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Thurs., May 26th.—11, Upper Belgrave Street, London, S.W.1, Annual General Meeting, 6 p.m.

INSTITUTION OF WATER ENGINEERS

Wed. to Fri., May 18th to 20th.—Richmond Hill Hotel, Richmond, Surrey, Sixtieth Summer General Meeting.

ROYAL AERONAUTICAL SOCIETY

Thurs., May 19th.—Royal Institution, Albemarle Street, London, W.1, Wilbur Wright Memorial Lecture, " Flight Control," C. S. Draper, 6 p.m.

ROYAL SOCIETY OF ARTS

Thurs., May 19th.—COMMONWEALTH SECTION : John Adam Street, Adelphi, London, W.C.2, " Scientific Research in India," Sir Alfred Egerton, 5.15 p.m.

ROYAL STATISTICAL SOCIETY

Wed., May 25th.—ORDINARY MEETING : School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, " A Unified Derivation of Some Frequency Distributions of Importance in Biometry and Statistics," J. O. Irwin, 5.15 p.m.